# IMPROVING KNOWLEDGE EXCHANGE FROM RESEARCH TO URBAN SUSTAINABILITY

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# ABSTRACT

This thesis explores knowledge exchange (KE) practices used by researchers and practitioners in the urban environment, aimed at improving urban sustainability. Using qualitative research methods and the case study approach, the research investigates the historical case of implementation of the Sustainable Urban Drainage Systems (SUDS) in Scotland, in order to illustrate practitioners-led KE. Furthermore, it analyses four case studies from the EPSRC-funded Sustainable Urban Environments Programme, in order to illustrate KE from the perspective of research.

To assess how KE practices' impact on urban sustainability can be improved, the thesis develops two new frameworks: (i) the *Engagement Benefits Framework,* assessing KE features associated with impactful collaborations; and (ii) the *KE Impact Assessment Framework,* assessing scattered impacts on complex environments, such as urban sustainability.

The analysis of data using both frameworks resulted in the identification of four engagement models: 'consultancy', 'co-production', 'advisory' and 'dissemination' models. The 'co-production' and 'advisory' models display the most of *engagement benefits*. They also score highest on the *KE Impact Assessment Framework.* It is therefore concluded that knowledge exchange characterised by *engagement benefits* can achieve better impacts on complex environments. The *KE Impact Assessment Framework* represents a static record of impacts achieved without recourse to information about causal relationships between them. To reflect the long-term process of alignment and change in the built environment illustrated by the SUDS case study, the assessment would need to be repeated. Lastly, KE's most essential outcome is the built capacity of practitioners, which enables them to contextualise and utilise the knowledge beyond the project and to reflect the changing requirements of sustainability transitions.

# DEDICATION

To my family.

ACADEMIC REGISTRY

# Research Thesis Submission

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# GLOSSARY

**1.** AMELIA - A Methodology For Enhancing Life by Increasing Accessibility
**2.** BMPs - Best Management Practices
**3.** CAR - Controlled Activities Regulations
**4.** CIRIA - Construction
**5.** CPD - Continues Professional Development
**6.** DEX - Dunfermline Expansion Area
**7.** IDCOP - Innovation in Design, Construction & Operation of Buildings for People
**8.** IEMA - Institute of Environmental Management & Assessment
**9.** ISSUES - Implementation Strategies for Sustainable Urban Environment Systems
**10.** KE - Knowledge Exchange
**11.** PACEC - Public and Corporate Economic Consultants
**12.** REF - Research Excellence Framework
**13.** SCOTS - Society of Chief Officers of Transportation in Scotland
**14.** SEPA - Scottish Environment Protection Agency
**15.** SfR - SUDS for Roads
**16.** SfS - Sewers for Scotland
**17.** SHBA - Scottish House Builders Association
**18.** SKINT - Skills Integration and New Technologies
**19.** SUDS - Sustainable Urban Drainage System
**20.** SUDS WP - Sustainable Urban Drainage System Working Party
**21.** SUE - Towards Sustainable Urban Environment
**22.** SW - Scottish Water
**23.** WDF - Water Framework Directive
**24.** WEWS - Water Environment and Water Services Act
**25.** WIR - Water Research Industry

# LIST OF PUBLICATIONS BY THE CANDIDATE

Przybycien, K., Beckmann, K., Pratt, K., Cooper, A., Crishna, N. and Jowitt, P. P. (2011) 'The ISSUES Project: An Example of Knowledge Brokering at the Research Programme Level' in Howlett, R. J., ed. Innovation Through Knowledge Transfer 2010, 297-307.

Crishna, N. and Przybycien, K. (2010) 'Bridging the gap – understanding the barriers to the exchange of knowledge between urban sustainability research and practice', The Environmentalist, 106, 14-18.

# CHAPTER 1 INTRODUCTION

## 1.1. Background

Sustainability became recognised as a global issue following the publication of "Our Common Future" also referred to as the Brundtland report by the World Commission on Environment and Development (WCED) in 1987 (Hulme, 2009). The notion of sustainable development, as well as the term, have a much longer history. It evolved in a series of earlier publications including, but not limited to: "Silent Spring", published in 1962 by Rachel Carson; "Limits of Growth" (1972) by the Club of Rome; "World Conservation Strategy: Living Resource Conservation for Sustainable Development" report (1980) following the International Union for Conservation of Nature and Natural Resources' (IUCN) conference or the "Building a Sustainable Society" (1981) by Lester Brown (Vojnovic, 2014).

A debate on how to implement the principles of sustainability followed, with international conferences marking the milestones at which progress or lack thereof was ascertained. The 1992 UN Conference on Environment and Development in Rio de Janeiro arrived at consensus amongst the 172 participating countries to endorse sustainability as a political objective. One of the results of the conference was the *Rio Declaration on Environment and Development (1992),* outlining 27 principles aimed at guiding progress towards sustainability. An action plan to advance those was called *Agenda 21,* which emphasised the urban aspect of sustainable development.

Urban environment is believed to witness the biggest challenges, and bear the gravest consequences of the unsustainable management of waste, pollution, health, energy or climate change. This is due to the fact that although urbanised areas occupy only 2% of the Earth's land surface, they are inhabited by 50% of the world population, and account for the consumption of 75% of the earth's resources (Deelstra and Girardet, 2000). The 1996 Habitat Conference focused specifically on consequences on urban environment, concluding that integration of social, economic, and environmental policy objectives was an imperative (Vojnovic, 2014). There was a consensus that progress depended on the proper management of many interrelated factors, but how those factors affected each other was contested. For example, the United Nations Development Programme (UNDP) uses multi-criteria indicators, such as the Human Development Index, which measures achievement in education, health and income. However, this socio-economic indicator does not account for political and ecological criteria, which may lag behind, as demonstrated by recent studies in some South American countries (Vojnovic, 2014). The

complexity of sustainable development, which makes it a challenging target to achieve and measure, is encapsulated by the definition:

"Urban sustainability is the economic, social, and physical organisation of cities and their populations in ways that accommodate the needs of current and future generations while preserving the quality of the natural environment and its ecological functions over time. While local in nature, urban sustainability must advance global sustainability; ensuring links between interdependent ecosystem processes and conditions at different scales, from local to global" (Vojnovic, 2014).

Therefore, it is perhaps not surprising that almost 30 years after the Brundtland report societies are still looking for solutions and mechanisms to implement urban sustainability and measures to reflect this progress. The challenges of implementation of the principles of sustainability have been acknowledged at the three environmental summits[1] following the Rio Conference. It was at the World Summit on Sustainable Development in Johannesburg in 2002 that the two major factors believed to be preventing its progress were identified. The first was "a general absence of knowledge, and agreement, on exactly how to achieve this condition" (Vojnovic, 2014) and the second named some countries' lack of political will to pursue sustainability. Addressing the first clearly fell within the remit of academic research; the second could be linked to knowledge exchange efforts aimed at influencing policy makers.

Different research programmes and networks across the world attracted research funding to investigate sustainability. For example, in 1998 European Union Environment and Climate RTD programme set up a BEQUEST Network, with a broad aim "to create a forum for concerted pan-European research, training and practical action in assessing the quality of the urban environment in order to identify the basis for a common understanding and implementation of sustainable urban development"[2]. The network of 14 partners from research institutions across Europe collaborated though a series of workshops and conferences.

[1]UN Climate Change Convention in Berlin (1995), Kyoto Conference (1997), UN General Assembly Session in New York City (1997)
[2]http://cibw117.com/europe/promoting-bequest-building-environmental-quality-evaluation-for-sustainability-through-time/

In the UK, research councils responded with funding assigned to various research programmes. One of them, "Towards Sustainable Urban Environment" (SUE), was funded by the Engineering and Physical Sciences Research Council (EPSRC) and consisted of a series of research projects focussing on various aspects of the urban environment. In 2002, it set up the first round of the programme through 12 UK-wide research consortia collectively referred to as SUE1. The programme's main aims were "to improve the quality of life of UK citizens, to support the sustainable development of the UK economy and to meet the needs of users of EPSRC funded research in industry. The SUE1 research fell into four clusters:

(i) Urban and built environment,

(ii) Waste, water and land management,

(iii) Transport

(iv) Metrics, knowledge management and decision-making

In 2007, EPSRC announced the second round of the programme: SUE2. It awarded funding to a further six consortia with additional objectives "to strengthen the UK research base in sustainability issues, and provide a platform for the research to reach the end users in industry, commerce, the service and public sector as well as to develop a strategic future research agenda in this area" (EPSRC, 2007).

In addition to adding the user-focus to SUE 2 objectives, EPSRC decided to sponsor focussed knowledge exchange projects to support the consortia. The project's title was Implementation Strategies for Sustainable Urban Environment Systems, in short ISSUES. Its aims were to both facilitate exchange of information between the consortia as well as disseminate their research outputs to policy makers and practitioners.

The idea that academic research could or should be used in the process of solving real world problems was shared, or perhaps triggered by the impact agenda, which had been developing in parallel at UK universities since the early 1990's. In 1993, the White Paper "Realising Our Potential", for the first time, referred to the role of academic research in the creation of 'wealth' and 'quality of life'. Gradually, impact criteria started to influence the process of research funding allocation (Holi et al., 2008). In consecutive years, a series of policy papers reinforced this trend. These included "Spending Review: Investing in Innovation: A Strategy for Science, Engineering and Technology" in 2002; "Lambert Review of Business - University Collaboration" in 2003; "10 year

Governmental Science and Innovation Investment Framework" or "Warry Report: Increasing the economic impact of Research Councils" in 2004 (Holi et al., 2008). Finally, in 2014, the Research Excellence Framework, an assessment exercise comparing research quality of the UK universities, for the first time included the criterion of impact. Although highly debated within and out with academia, impact is believed to be an important aspect in research assessment in the future.

This doctoral Thesis forms part of the aforementioned ISSUES project. It explores knowledge exchange mechanisms used by the SUE consortia, including the ISSUES project that is aimed at the implementation of research findings in professional urban practice. Further, it examines a case of Sustainable Urban Drainage Systems (SUDS) to contextualise knowledge exchange efforts within a long-term sustainability transition process in the built environment. In so doing, it links the agendas of research impact and urban sustainability.

## 1.2. Research aim and objectives

The overall research aim was to explore how knowledge exchange from research can improve urban sustainability. In order to achieve this aim, following research objectives with corresponding questions were formulated:

Objective 1: Identify and assess characteristics of knowledge exchange processes that affect their effectiveness in making an impact

Questions:

1. What knowledge exchange practices are used by researchers and practitioners in the area of urban sustainability?
2. How to define effectiveness of knowledge exchange in the context of urban sustainability?

Objective 2: Develop a method for assessment of knowledge exchange impacts on urban sustainability

Questions:

1. How to measure impact on urban sustainability?
2. What impacts have been achieved by SUE research projects?
3. How did the new sustainable SUDS practice became embedded in the built environment?

## 1.3. Thesis outline

Chapter 1 contains the background and explains how the urban sustainability agenda developed and led to the "Towards Sustainable Urban Environment Programme" (SUE). It defines the scope of research, its aim, objectives, and questions.

Chapter 2 refers to theories of knowledge and models and factors affecting knowledge exchange based on literature. It explores ways of assessing the effectiveness of knowledge exchange in making impact in the real world.

Chapter 3 explores the built environment as a context for sustainability innovations and discusses the challenges of defining and measuring progress towards sustainable development.

Chapter 4 summarises the literature review and proposes arguments for the creation of two frameworks: one assessing knowledge exchange with regard to *Engagement benefits*, and the other assessing impacts of projects on urban sustainability.

Chapter 5 describes the methodology used in the thesis, including epistemological considerations, methods of data collection and analysis, and the contexts for case studies selection.

Chapter 6 presents the case of Sustainable Urban Drainage Systems (SUDS) in Scotland. It analyses selected implementation milestones of SUDS, factors affecting the process and engagement mechanisms used by SUDS champions and the SUDS Working Party.

Chapter 7 presents the data and data analysis for the Sustainable Urban Drainage System case study. It explored the elements of the *Engagement Benefits Framework* and the *Impact Assessment Framework* from a long-term perspective of a mature case of the implementation of sustainable innovation in the built environment.

Chapter 8 describes the four case studies selected from the Sustainable Urban Environment programme: AUNT SUE, IDCOP, Sustainable Eastside and the ISSUES project.

Chapter 9 presents the data and analysis of the SUE case studies, using the *Engagement Benefits Framework* and resulting in the development of four models of engagement. It further analyses the impacts achieved by the projects on the *Impact Assessment Framework*.

Chapter 10 presents conclusions from the thesis.

# CHAPTER 2 KNOWLEDGE EXCHANGE

## 2.1. Introduction

This chapter looks at knowledge and the processes involved in moving knowledge between various contexts. It explores how literature divides knowledge, which knowledge types are prevalent in academia, and what the relationship is between knowledge and innovation. It further defines knowledge exchange (KE), its mechanisms, and its models, and examines how the effectiveness of KE is defined and measured.

## 2.2. Knowledge

Knowledge "...is a magic term with multiple connotations and interpretations" knowledge (Augier and Thanning Vendelø, 1999). It plays a critical role in the world of academia, constituting its founding ingredient as well as its main output. In the process of teaching and research, knowledge is routinely generated, updated, used and reproduced. Academic careers revolve around the generation and dissemination of explicit knowledge, through publications and teaching. There are also vast reservoirs of tacit knowledge generated and utilised alongside. Wright (2008) argues that "the knowledge that underlies skilful performance at universities is in large part tacit knowledge, in the sense that scientists are not fully aware of the details of their skills and find it difficult or impossible to articulate a full account of those details".

### 2.2.1. *Knowledge types*

A basic classification of knowledge distinguishes between two types: tacit and explicit (Polanyi 1966; Nonaka, 1994). Tacit knowledge is "deeply rooted in action, involvement and commitment within a specific context" (Cummins, 2003). Explicit knowledge is defined as fact-based, quantifiable evidence, which is "expressed in words, numbers, and other symbols" (Hartley, 1994). Technology is "a kind of knowing how", a set of beliefs, routinized knowledge" (Augier and Thanning Vendelø, 1999) and as such falling into the tacit category, however it is also seen as a tangible "representer of knowledge (Augier and Thanning Vendelø, 1999), most commonly as an artefact or a tool (Bozeman, 2000). There are many more typologies of knowledge beyond the tacit vs. explicit divide, using different criteria to distinguish between different types of knowledge. These include:

a. Relationship with existing system of knowledge: independent vs. system based (Winter, 2004)

b. Complexity: simple vs. complex (Winter, 2004; Rogers, 2003; Zander, 1995)
c. Source: research derived, disciplinary, experience (Caraca, 1994)
d. Impact on science: normal vs. revolutionary (Kuhn, 1970)
e. Degree it can be communicated or moved: articulated through linguistics tools or artefacts vs. non-articulated (Winter, 2004; Zander, 1995)
f. Observability of non-articulated knowledge: observable in use vs. non-observable (Winter, 2004; Rogers, 2003; Zander, 1995)
g. Novelty – innovation and invention (Rogers, 2003)
h. Scientific, interpretive and procedural (Symes, 2007)

The awareness of the multiplicity of knowledge types and categories enhances the understanding of the opportunities and limitations inherent to each of them, for example in relation to their ability to be moved between contexts and stakeholders.

### 2.2.2. *Transferability of various types of knowledge*

The most fundamental difference between tacit and explicit knowledge types is that of transferability. It becomes clear in the process of trying to locate, acquire or move each the different types. Tacit knowledge "is held in a non-verbal form, and therefore, the holder cannot provide a useful verbal explanation to another individual [...] (Augier and Vendelø, 2003), it "is acquired through experience (Polanyi, 1966). Explicit knowledge is transmittable in formal, systematic language" (Cummings, 2003). "It can be expressed in symbols and communicated to other individuals by the use of these symbols" (Schulz, 1998 in Augier and Vendelø, 2003). The possibility to express explicit knowledge makes it articulable (Winter, 2004). If knowledge is articulable and articulated, it can be taught and can be passed further. If it is articulable but not articulated, it becomes like the tacit knowledge, and remains obscured to others, unless it can be observed independently of the intention of its owner. Teachability or movement of knowledge is believed to require varied techniques for knowledge that is complex as opposed to simple knowledge. It is also assumed to be easier to move knowledge that is independent rather than part of the system, where it may depend on other elements of the system to be moved or applied. The owners of the tacit knowledge can facilitate its movement, or allow others to access it by enabling observation, if the knowledge can be enacted. Re-enactment of that knowledge by observers can generate tacit understanding within them. Enactment of explicit knowledge acquired by reading, listening or interaction might lead to similar effects (Davenport and Prusak, 1997). When the enactment is based on trial and error, it

can be described as “learning by doing”. The movement of tacit knowledge between parties implies that in-depth understanding and learning, possibly unrealised by the learner is taking place.

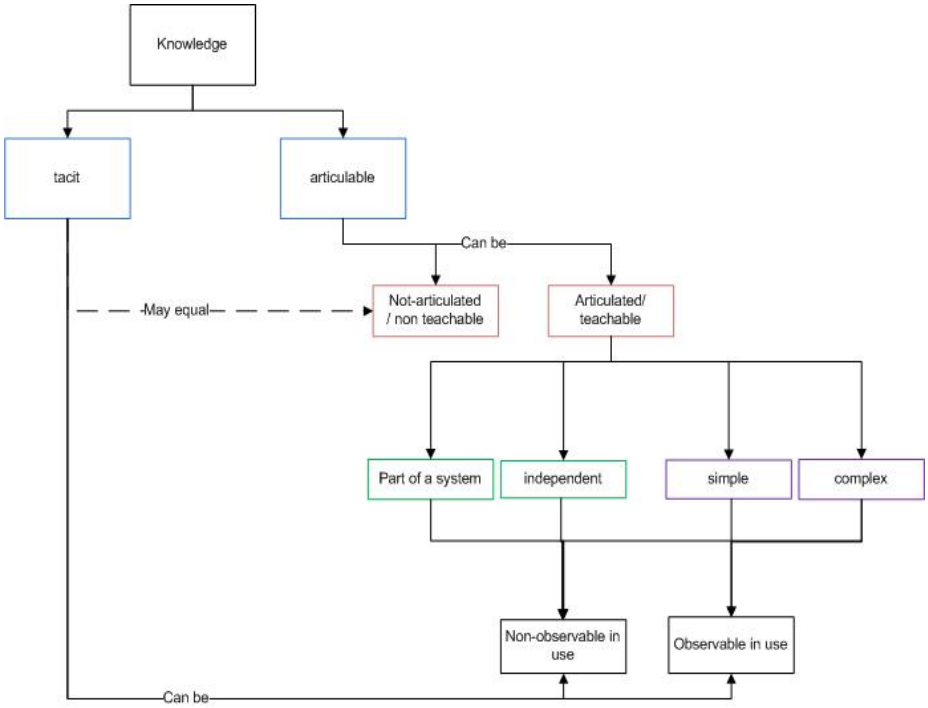


Figure 1 Categorisation of knowledge with respect to its transferability

### 2.2.3. *Innovation*

An innovation describes an idea, practice or an object. Innovation is not necessarily objectively new “as measured by the lapse of time since its first use or discovery” as long as its adopter perceives it as new (Rogers, 2003). Research-generated knowledge tends to be objectively new and is referred to as invention (Rogers, 2003). In that, the division between research-derived knowledge, previously referred to as invention and disciplinary knowledge is less relevant in the context of generating innovation in the world of practice. Both the truly new, and the newly applied established knowledge, can lead to innovation in the world of practice.

## 2.3. Knowledge exchange

### 2.3.1. *Definition of Knowledge Exchange*

Knowledge exchange is a broad concept defined as ‘‘a process of generating, sharing, and/or using knowledge through various methods appropriate to the context, purpose, and participants involved’’ (Fazey et al., 2014). It encompasses a range of concepts such as co-production, transfer, storage, transformation, integration and translation of knowledge

as well as social learning" (Fazey et al., 2013). Prior to the emergence of the concept of knowledge exchange many techniques and activities, now called KE, were undertaken by academics and driven by an inquisitiveness inherent to the process of research aimed at contributing to the widely understood advancement in the world of knowledge and practice. A related term of "knowledge transfer" was then used in relation to mostly commercial interactions of research with the private sector. The term knowledge exchange emerged as a consequence of the evolved understanding of the nature and diversity of interactions of research with all sectors of economy and society. It gained importance when research impact was added as a criterion within the Research Excellence Framework, measuring contribution of research to the world of practice. Knowledge exchange was meant to trigger, facilitate or increase serendipity inherent to the occurrence of such impacts.

### 2.3.2. *Knowledge Exchange channels*

The structured and unstructured interactions between the world of academia and society, policy, commerce or industry can be facilitated by people, artefacts, activities and the written word and are referred to as engagement processes, knowledge transfer instruments or channels (Bekkers and Bodas Freitas, 2008; Salter and Gann, 2001; D'Este and Patel, 2007). They embrace a mix of activities aimed at income generation, dissemination and labour mobility. Some authors consider teaching to be a KE channel (Holi at el., 2008; PACEC, 2009) whereas others considered it to be so only if external stakeholders are involved (Salter and Gann, 2001). Some authors only consider channels that can be quantified objectively (Bekkers and Bodas Freitas, 2008; Salter and Gann, 2001; D'Este and Patel, 2007), and others include those measured by personal recollection of engagement nature and frequency (PACEC, 2009). Individuals, organizations and projects use KE channels in different ways, sometimes as individual channels, and sometimes as a selection of many channels forming part of an engagement strategy.

### 2.3.3. *Obstacles to knowledge exchange*

Common obstacles to knowledge exchange result from the use of jargon, long formats, complexity and irrelevance to real world problems, and the publication of results in locations never accessed by practitioners (Moncaster et al., 2010). They reinforce the long discussed *two communities* divide between us and them (Caplan, 1979). Crishna outlines the differences between the end-user and the researcher perspectives in the process of knowledge exchange (Crishna and Przybycien, 2010), see Table1.

Table 1 Barriers to knowledge exchange (Crishna and Przybycien, 2010)

| End-user perspective | Researcher perspective |
|---|---|
| - Relevance /applicability of research<br>- Difference in timescales<br>- Dissemination routes<br>- Cost (in terms of money and time) of engaging with research<br>- Format of research outputs<br>- Lack of established relationships<br>- Relevance of seminars/conferences<br>- Lack of familiarity with academic research process | - No incentive to disseminate beyond peer-reviewed outputs/engage with end-users<br>- Lack of understanding of target end-users<br>- Insufficient time/resource for KT and engagement<br>- Timescales/needs of end-users differ with those of research<br>- Not enough expertise/training in KT and communication<br>- Nature of research contracts<br>- Private sector/public bodies have minimal time and budget for KT events, or for CPD<br>- Insufficient support from government for KT of academic research<br>- Reluctance of researchers to formally share their results with others<br>- Communication issues arising from interdisciplinarity of research teams<br>- Insufficient prioritisation of sustainability by target end-users |

The existence of a gap between theory and practice also applies to academic research practice itself. Research on the perceptions of researchers and practitioners about the relevance of academic work to professional practice show their opinions to be far apart (Crishna and Przybycien, 2010). The ISSUES project research, based on self-assessment of both groups, created matrices comparing perceptions of what they thought was required for making research relevant to practice (knowledge demand) and how well the current practices addressed those criteria (knowledge supply) (Crishna and Przybycien, 2010). It revealed a mismatch between the perceptions of academics and professionals regarding knowledge supply and demand (Crishna and Przybycien, 2010) in the built environment. It highlighted the gap between the perceptions of academics

and practitioners regarding the relevance and accessibility of their research to the real world needs. Researchers seemed to be unaware of the way the external stakeholders perceived the effectiveness of their efforts to communicate and exchange knowledge. Additionally it showed how professionals access new knowledge and what obstacles they face when looking for new knowledge (Cloughley and Beckmann, 2010). Based on those finding, ISSUES focus mainly on facilitating more effective communication between researchers and end users of research by increasing knowledge accessibility and availability as well building KTE capacity amongst SUE researchers. Working on the research programme level, ISSUES performed functions comparable to knowledge brokers (Przybycien et al., 2011). Activities undertaken by the ISSUES addresses a series of barriers identified, see Table 2.

Table 2 The ISSUES strategy vs. KE barriers

| Obstacles to KTE | ISSUES way of addressing the obstacle |
|---|---|
| Jargon and convoluted language | translation of research results using plain English |
| Difficult or lack of access to academic research | publishing research summaries in trade magazines and general newspapers as well as online |
| Lack of awareness about research | promoting research using social media, video, exhibition and popular events |
| Lack of advocacy for research | proactive advocacy with policy makers and authorities |
| Information scattered across various information platforms | publishing research results in one place and providing research gateway and experts |
| Lack of opportunities for face to face contact | by organising networking events |

Based on the project experiences a series of guidance materials and briefing papers were produced that remained available online.

### 2.4. Research utilisation

Knowledge Exchange's ultimate objective of leading to impact can only be achieved by the utilization of knowledge in question. Zhang et al. state: "knowledge will not bring any value unless it is used actively" (Zhang et al., 2009). Innovation studies also suggest that it is the application of knowledge, rather than its creation, that triggers innovation (Rogers, 2003). Nutley (2007) points out that knowledge utilization can be conceptual,

where it may affect one's attitudes, awareness and knowledge, or instrumental, where it turns into action. Prior to Nutley's binary typology, authors attempted to map the stages of research utilization by professionals from the moment they received the knowledge (Knott and Wildavsky, 1980; Glasziou, 2005; Davenport and Prusak, 1997). The stages suggested by different authors overlap to some extent (Table 3).

Table 3 Stages of research utilisation.

| Davenport & Prusak (1997) | Knott & Wildavsky (1980) | Glasziou (2005) | Nutley (2007) |
|---|---|---|---|
| Read/ review | Reception & Cognition | Aware and accept | Conceptual |
| Act on / discuss | Reference | View as logically applicable and locally doable | |
| Argue/ defend Present / teach | Effort | Act on | Instrumental |
| Simulate / live | Adoption | Adopt | |
| | Implementation | Adhere | |
| | Impact | | |

The aforementioned stages of research utilisation imply that the process of research use is linear. This notion has been criticised in literature and an alternative of a "research use continuum" was proposed (Nutley et al., 2007). It assumes that the various stages of research use are continuously repeated and reiterated. Despite its shortcomings, the mapping of stages of research utilisation identifies behaviours or processes involved in, or associated with, the conceptual or instrumental use of knowledge. Neither of the conceptualisations assumes that the source of the knowledge that is being processed by the practitioner is present at any point of the research use. Instead, they suggest that the use of knowledge, that has been successfully handed over to the practitioner is entirely dependent on their motivation, skills, and ability to do so. Davenport and Prusak's (1997) framework conceptualises how the level of engagement of the recipient with the new knowledge leads from their awareness to application. They propose a scale of five levels of engagement (see Fig.2). The least engaging level "Read / Review" channel on the bottom of the scale refers to traditional printed materials. The engagement is solely on the side of the recipient who has to read or review a written text. The medium of written text is very efficient in conveying complex, explicit knowledge and can be accessed simultaneously by a large number of recipients, but it depends entirely on the recipients'

ability and motivation to read and understand it, and it is much less effective in changing their motivation, attitudes or behaviour. This applies even if it is similar to the format and complexity of information those recipients usually consume. If the written text is an academic publication, the jargon and complexity become a major obstacle for non-academic audiences to access and understand it (Crishna and Przybycien, 2010). Interestingly, if the context of practice is similar to the context of research, for example in the R&D departments of companies, the use of jargon, the style or the complexity of knowledge conveyed in academic publications are not perceived as obstacles to its use (Schartinger, 2002). The level of "Read / Review" based on dissemination of written materials has no implications for lack of engagement, nor incentives for the reader to engage with it. The potential reader needs to find and access the materials, possess ability and willingness to read and to understand them. The next level called "act on/discuss" implies that the recipient understood the content and is able to refer to it in a discussion, but is indifferent to it. The next level called "Argue / Defend" implies the creation of an emotional attitude, where the recipient needs to take a stand on the knowledge presented, and possibly defend it. Davenport and Prusak (1997) suggests that starting with level two, additional factors come into consideration. These are *content attributes* such as: brevity, visual appeal, concreteness, uniqueness emotion; *attributes of the source* such as features of the person(s) communicating or author(s) of the knowledge come into play: power, objectivity, familiarity, personal appeal and perceived expertise; and *attributes of the situation* including the consequences and motivational factors for the recipients (Davenport and Prusak, 1997).

The next level "Present / Teach" suggests that the recipient becomes the new owner or source of the knowledge for those who they present to or teach. It requires a good understanding of the topic. The top level of Davenport and Prusak's scale of engagement, called "Simulate / Live", involves utilisation of knowledge, where its user can perform, test and experience it first-hand. Similarly, to the aforementioned mappings of research utilisation, Davenport's model is linear. It assumes that the build-up of a vested interest and expertise in the new knowledge is gradual and starts with the user reading a written text. It also suggests that the change of behaviour follows the same gradual steps. While acknowledging the weaknesses of the framework, it is interesting in suggesting that the transformation of the user of knowledge into its owner is supported by the gradual creation of an emotional link, learning and interactions with others about the knowledge.

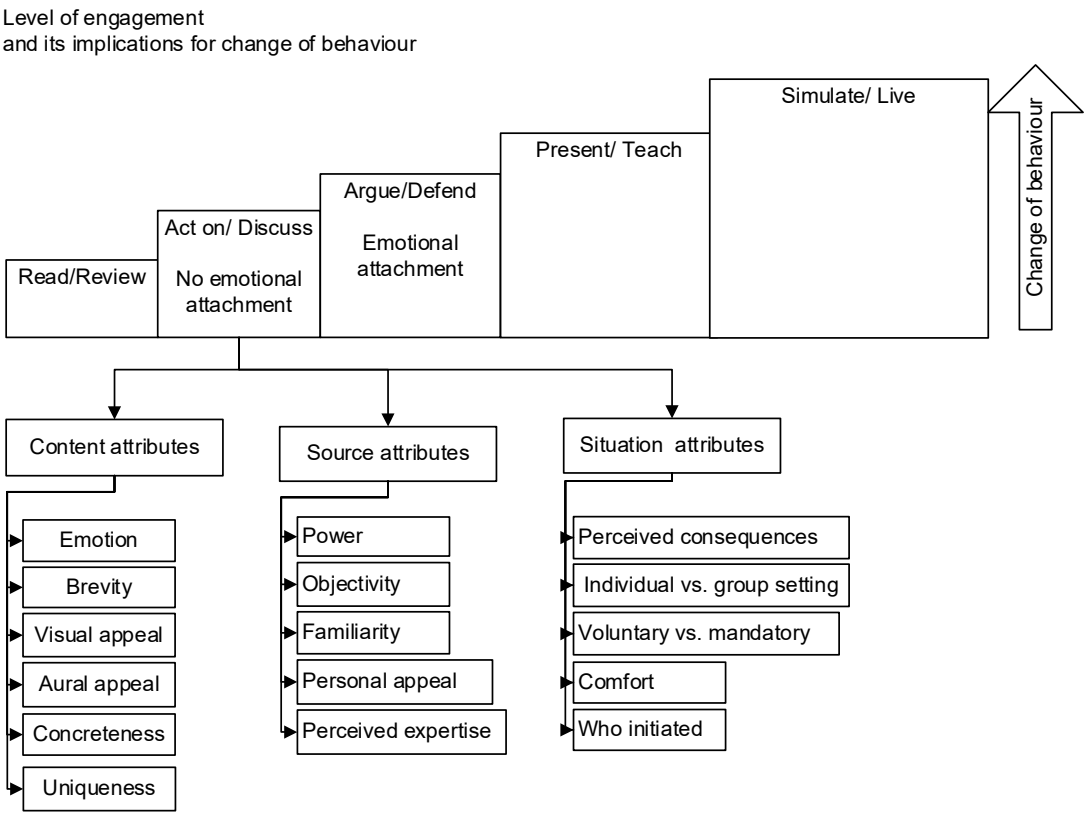


Figure 2 Levels of engagement (Davenport and Prusak, 1997)

## 2.5. Models of knowledge exchange

Knowledge Exchange models are generalisations and conceptualisations of KE processes describing their purpose or interplay of their building components, such as knowledge source / author; knowledge recipient / utilisation context; method of communication and collaboration.

### 2.5.1. *Linear models*

The linear models of knowledge exchange are built on several assumptions. The two most important are:

- The knowledge source is different from the knowledge target audience, therefore it is necessary to link the source with the audience.
- The knowledge produced in one context (that of research) can be applied in the same format in another context (that of practice).

Based on those assumptions, making knowledge available and accessible through appropriate dissemination channels should determine its uptake. The linear models can diversify the channels, adjust the language and enhance visual appeal of the knowledge presented. The main premise is to push the knowledge out, hence many have called it the

"push" model (Nutley et al., 2007). Over time, this model was enhanced by considering practitioners' preferences or habits with regards to their knowledge sources. So pushing knowledge towards locations which were specific or attractive to practitioners added the "pull" element to the model. Despite the focus shifting to the users, these models remain linear in nature: information flows from the source in academia to the destination in practice, broadly unchanged. Boaz (2000), in her literature review refers to this approach as getting the information "to the door" of the practitioner.

This linear process, although allowing researcher to link their newly generated knowledge with its user, has several weaknesses. The three most prominent in the context of research exchange are:

(1) Researchers lose control over the knowledge they pass over and influence over the recipient.

By handing over the research to the user with no further interaction, the researchers have no knowledge nor ability to influence how the user is dealing with challenges related to utilisation of the new knowledge, whether conceptual (e.g. accepting, understanding, perceiving applicable and doable) or instrumental (acting on, adopting, adhering, negotiating external factors).

(2) Uncertainly about research fidelity during utilisation.

The issues of research fidelity and implications of research misuse are in themselves obstacles preventing researchers from engaging in knowledge exchange (Patton, 1997). The fears of researchers that their research could be 'improperly' used are not unfounded. Gomm (2000) claims that fidelity of research, which is its faithful replication it in different context is rarely possible. In most cases, the process requires trade-off between more local and mode generic processes (Nutley et al., 2007) despite would often provide best results (Mihalic, 2004 in Nutley et al., 2007). In addition, the intention to use knowledge may be dropped altogether by practitioner perceiving it unsuitable for use in a local context or contradictive to the mainstream approach as documented by Nutley on the example of policy makers (Nutley et al., 2007)

(3) Two communities

The linear model reinforces the divide between us and them, the knowledge producers and users, known in the literature as the *two communities* theory (Caplan, 1979).

### 2.5.2. ***Interactional models***

Two of the assumptions underlying the interactional models include:

- Knowledge is produced by both researchers and practitioners both in their own contexts, as well as collaboratively, and often lead to the creation of something qualitatively new (Tyden, 1993).
- Knowledge is highly contextual and its use is influenced by a complex range of contextual factors: organisational, cultural political, personal (Huberman, 1994; Nutley at al., 2007)

Interactional models enable feedback and mutual learning, and help to overcome the *two communities* divide by adjusting language, and frame sharing enhancing understanding of each side's limitations. These features of dialogue, interaction, and continued feedback loop are believed to support creation of new knowledge that is validated by both sides, and reinterpretation or contextualisation of knowledge is created in one context to fit another (Huberman, 1994). Furthermore, direct exchange allows in-depth understanding and entitlement to reproduce the newly created knowledge, allowing "both sides laying claims to conceptual power and replicability" Huberman (1994). Huberman further argues that a "situation of relative symmetry, in which the researchers are no longer delivering their knowledge base to practitioners and leaving the scene […] is often a prerequisite to significant learning, especially among adults" (Huberman, 1994). This supports local reinvention of research, and reduces the likelihood of local resistance to implementation (Nutley and Davies, 2000).

Interactional models of knowledge exchange offer an opportunity for creation of trust between involved parties. Studies looking at trust between individuals and groups involved in collaborative projects between academia and the world of practice (Jarratt and Ceric, 2015; Cummings and Bromiley, 1996; Adobor, 2005) suggest it has a positive effect on the performance of collaborations, and enhances learning on both sides (Ybarra and Turk, 2009). Some studies go further and claim that trust is the most important factor contributing to the successes of collaborations (González del Campo et al., 2014), as explained by others, trust and the feeling of dependence increase the likelihood of knowledge sharing (Park and Le, 2014).

Trust can be defined as "an accumulated product of repeated past interactions among parties through which they come to understand themselves and develop a common knowledge of mutual commitments" (Hou, 2014). The creation of trust is supported by "relationship equity, shared values and communication" (Ybarra and Turk, 2009). Park and Le (2014) suggest that the creation of trust depends on "the communication frequency, perceived similarity of the project's value, and the perceived expertise". In

summary: trust, learning, and equity of relationship are interlinked. Trust emerges from repeated interaction and increases learning; equity of relationship increases learning and creates trust; and higher levels of participation enhances learning (Santoro and Saparito, 2003 and 2006; Evely et al., 2011).

In addition, engagement processes enhance the chance of serendipitous personal connections, and informal networks (Wright 2008, Bekkers and Bodas Freitas 2008).

### 2.6. Measuring knowledge exchange

In order to assess knowledge exchange with regards to its effectiveness in achieving its main objective of facilitating impact, it needs to be measured. Measurement of a diverse range of activities - both structured and unstructured and their effects, poses a considerable challenge. The most frequent metrics of knowledge exchange that can be applied to the majority of activities are based on the quantification of the frequencies of use of specific KE channels (e.g. number of non-academic conferences attended) or types of interactions between universities and stakeholders such as firms (Schartinger et al., 2002; Bekkers and Bodas Freitas, 2008; Salter, 2010; Arza, 2010), communities, policy, and general public (PACEC, 2009). Holi (2008) provides a list of metrics routinely used to measure Knowledge exchange channels (Holi et al., 2008), see Table 4.

Table 4 Metrics for the Evaluation of Knowledge Exchange activities (Holi et al., 2008).

| Mechanism of Knowledge Transfer | Measures of Quantity | Measures of Quality |
|---|---|---|
| Networks | # of people met at events which led to other Knowledge Transfer Activities | % of events held which led to other Knowledge Transfer Activities |
| Continuing Professional Development (CPD) | Income from courses, # of courses held, # people and companies that attend | % of repeat business, customer feedback |
| Consultancy | # value/income of contracts, % income relative to total research income, market share, # of client companies, length of client relationship | % of repeat business, customer feedback, quality of client company, importance of client relative to their company |

| | | |
|---|---|---|
| Collaborative Research | # value/income of contracts, market share, % income relative to total research income, length of client relationship | % of repeat Business, customer feedback, # of products successfully created from the research |
| Contract Research | # value/income of contracts, market share, % income relative to total research income, length of client relationship | % of repeat Business, customer feedback, # of products successfully created from the research |
| Licensing | # of licenses, income generated from licenses, # of products that arose from licenses | Customer feedback, quality of licensee company, % of licenses generating income |
| Spin-Outs | # of spin-outs formed, revenues generated, external investment raised*, market value at exit (IPO or trade sale) | Survival rate, quality of investors, investor/ customer satisfaction, growth rate |
| Teaching | Graduation rate of students, rate at which students get hired (in industry) | Student satisfaction (after subsequent employment), employer satisfaction of student |
| Other Measures | Physical Migration of Students to Industry,<br>Publications as a Measure of Research Output | |

Activities that other authors consider the most effective enablers of knowledge exchange fall into the less tangible or measurable category of people-based activities, including staff movement, informal meetings, advice given, memberships at boards, networking (Bekkers and Bodas Freitas, 2008; Arza, 2010; Schartinger, 2002; Salter, 2010; D'Este, 2007). Other challenges facing impact measurement include evidencing causal relationships between research outputs, knowledge exchange and impacts have been widely analyzed (Boaz et al., 2008; Phillipson et al., 2012; Davies et al., 2008). These resulted from difficulty to separate the contributions of projects from those of external factors (including political, economic, social, cultural and institutional). Literature suggests that different approaches are adopted to overcome these challenges. Those focus on measuring input and its effectiveness to pass the knowledge to practitioner (Boaz et

al., 2008). Boaz refers to those approaches as "to the door". Fazey's review identifies some further categories of evaluation strategies (Fazey et al., 2014). The classification of 135 evaluation studies (according to what they focused their measurements on) suggested four broad areas where evidence for impact was sought, including:

- *Processes*, included assessment of the nature and/or quality of the knowledge exchange process, i.e. how or how well knowledge is conducted.
- *Understanding*, included immediate effects on individuals, e.g. increased awareness, understanding or knowledge, attitude change, and other intangible effects; which can be described as "conceptual" research use (Nutley et al., 2007).
- *Practice change*, including behaviour, practice or policy change, and correspond with the "instrumental" research use (Nutley et al., 2007).
- *Impacts of practice change*, understood as the long-term impacts resulting from behaviour or policy changes, e.g. improved health or environmental protection (Fazey et al., 2014).

The Table 5 below presents the detailed list of indicators for each category.

Table 5 Evaluation criteria coped from (Fazey et al., 2014)

| Processes |
| --- |
| o Level of Knowledge Management: to what extent knowledge management is implemented; existence/absence of strategies;<br>o Satisfaction: participants satisfaction and experience of the KE process,<br>o Communication/relationships: what are the relationships or roles of the participants, how do they communicate and what is the quality of the relationships and communication<br>o Participation: how many stakeholders were enabled to participate, how much did participants engage in the KE<br>o Efficiency: (cost) efficiency of KE in achieving its aims and affordability; Sustainability: sustainability of the setup of the KE or the participating institutions;<br>o Quality of information content: quality of information exchanged; Knowledge: characteristics of knowledge used in the KE and its sources;<br>o Methods of KE: methods that are used for KE by participants;<br>o Leadership: Degree, location and quality of leadership in the KE process;<br>o Functionality and effectiveness: Functionality, applicability or effectiveness of a KE approach or tool, |

| |
|---|
| ○ Formal process: Quality/suitability of the formal rules and of the implementation of the KE process; suitability of surrounding conditions and support,<br>○ Barriers to KE: What barriers and challenges hinder the KE, Ways to improve KE: how could the KE process be improved. |
| Understanding |
| ○ Increased knowledge, awareness or understanding<br>○ Skills: new skills learned by participants<br>○ Attitude and attitude change<br>○ Intention of behaviour change<br>○ Confidence: increased confidence in participants<br>○ Innovation: creation of innovations and new ideas<br>○ New structure: new networks or structures are set up, communication is improved<br>○ Provision of information: amount/quality of new information provided<br>○ Identification of further needs or action<br>○ Symbolic/political use of knowledge |
| Practice change |
| ○ Individual behaviour change<br>○ Use of new technology or tool<br>○ Decisions made<br>○ New evidence integrated into policy/strategy<br>○ Change in organisational process or decision making<br>○ Creation of new institution, system or project: Includes only outcomes of KE, not the KE itself<br>○ Further sharing of knowledge<br>○ Use of knowledge |
| Impacts of practice change |
| ○ Ecological health<br>○ Social and economic welfare<br>○ Social equity/participation<br>○ Business performance<br>○ Quality of health and health care<br>○ Capacity built<br>○ Benefits for stakeholders involved |

The challenges to evidencing causal relationships (between research outputs, knowledge exchange and impacts) by separating out their contribution from that of external factors

(including political, economic, social, cultural and institutional) have been widely analysed (Boaz et al., 2008; Phillipson et al., 2012; Davies et al., 2008). The most salient challenges are the likely delays between the research and KE interventions and the occurrence of impacts and the attribution of many other factors to the developed of impact in the real world. In addition, often limited and time-bound participation of researchers in the process of research utilisation provides limited opportunities to witness the process of instrumental and conceptual utilisation of knowledge.

The categories of impact presented above are very broad. For example, impact on the area called "Understanding" includes a wide spectrum of impacts that can be achieved and measured on individuals - from awareness to skills, attitudes and or intentions to change behaviour. These are prerequisites, which precede action. The area of *practice change* is also very broad, including both individual behavioural change and decisions are made to change policy and organisational rules affecting large groups of people.

# CHAPTER 3 URBAN SUSTAINABILITY

## 3.1. Urban Environment

The Urban Environment is a broad term encompassing physical infrastructure with a wide range of stakeholders and processes involved in its design, creation, management and use; reflecting too the needs, wants, and values of these stakeholders (McClure and Bartuska, 2007). In short, it encompasses the construction sector that is creating or revitalising its physical interface, the built environment, its physical forms, and people who manage, use or are affected by it.

Urban environment can most significantly be influenced at the stages where its physical infrastructure is in the design, construction, reconstruction or deconstruction stages, in other words, where it is undergoing physical change, though it can also be affected whilst in use.

There is a consensus, reiterated by the Stern Review (Shipworth, 2007), that in order to combat climate change, urban environment requires 'more and faster' innovation.

Urban environment is characterised as less innovative than other sectors (Yitmen, 2007), due to factors including:

- Slow depreciation rate of its physical assets, which decelerate processes of development and uptake of innovations (Rennings, 2000).
- Industrial lock-ins that results in professionals being more likely to choose solutions or building materials available on the market over new, improved ones that would actually improve urban sustainability (Kemp and Camphuijsen, 2008 in Farla et al., 2012).
- Fragmented, multi-stakeholder, interconnected, and complex composition.
- Operating within the construction sector that is capital-intensive, highly regulated, risk averse, and with high legal liabilities (Davey-Wilson, 2001).

It also depends on the changes to human behaviour, including strengthening of civil society, institutions, engagement and values and beliefs (Fisher, 2012).

## 3.2. Innovations for sustainability

An innovation describes an idea, practice or an object, which is not necessarily objectively new "as measured by the lapse of time since its first use or discovery", but can be considered as new so long as its adopter perceives it as being so (Rogers 2003).

In contrast, research generated knowledge tends to be truly new and is referred to as invention (Rogers 2003).

Challenges to adoption of innovation can come from the context in which it is intended to be used and the characteristics of the innovation itself. The aforementioned structural characteristics of the built environment already pose challenges to innovations. They are further reinforced by the complexity of each construction project ”comprised of a diverse organisational settings, which bring together complementary knowledge and expertise for serving the needs and the purposes of specific projects” (Nikas et al. 2007).

Sustainable innovations further complicate the process, as they are often not associated with immediate benefits. They are often called “preventive innovations” as they fulfil that function of bringing benefits that are potentially beyond the reach of the adopter and are more likely to prevent something from happening, serving a wider good than that directly represented or embodied by the adopter (Rogers 2003). Moreover even small changes can trigger wide-ranging further innovation with regard to technology and knowledge (Rennings 2000) and hence require further engagement and alignment of all stakeholders from the “building product supply chain, from concept design to operation” (Nikas et al. 2007, Rezgui, Wilson et al. 2010). Nahuis (2012) refers to it as ”frame sharing” or an “emerging alignment among social groups pertaining to goals, key problems, problem-solving strategies, theories, tacit knowledge, users' practices, perceived substitution function, and exemplary artefacts (Nahuis et al. 2012).

The structural factors affecting change in the urban environment are coupled with the willingness and attitudes of people within the industry, which is aptly described by McClure and Bartuska (2007): “sustainability is entirely dependent on human attitudes, knowledge, innovativeness, ability and willingness to make it sustainable" (McClure and Bartuska 2007). The people-related facet of sustainability provides an entry point accessible to knowledge exchange processes and efforts, whereas the traditional knowledge transfer dealt with technological innovations.

Literature offers a variety of classification models. The distinction between stakeholders who “can affect and affected” fulfils a landmark position (Freeman, 1984 in Vos, 2006).

### 3.3. Knowledge in Urban Environment

The complexity of the built environment and its socio-technical facets generate a demand for both social and technical types of knowledge. Symes and Pauwels (2007) add three further dimensions to the knowledge required for urban design:

(i) Scientific knowledge, describing the characteristics and interaction of the built form with the rest of the physical world;

(ii) Interpretive knowledge, describing understanding of the social world and human interactions with the built form;

(iii) Procedural knowledge, which comes from internalised experience and results and a tacit ability to evaluate the options for interventions in the 'socio-technical' systems (Symes and Pauwels, 1999)

Zhang (2009) further includes in the explicit category: "project information, design drawings and specifications, cost reports, risk analysis results, and other information being collected, stored, and archived in paper or electronic format" and in tacit category: "the experience and expertise kept in the construction professional's mind, company culture, lessons learned, know-how, and other elusive yet valuable information".

### 3.4. Stakeholders in the BE

The built environment's physical infrastructure is created by the construction industry. The construction process takes place by the means of individual projects, each involving a whole range of diverse stakeholders (Bennett, 2003). A project stakeholder is a person or group of people who have a vested interest in the success of a project and the environment within which the project operates." Projects can have a large number of stakeholder involved, interwoven with each other in a variety of ways through collaboration, co-investment or regulatory interdependencies (Chinyio and Akintoye, 2008). These include: "owners, users, project managers, facilities managers, designers, legal authorities, subcontractors, suppliers, process and service providers, competitors, banks, insurance companies, community representatives, general public, government establishments, visitors, customers, regional development agencies and the media (Newcombe, 2003; Smith and Love, 2004 in Chinyio and Akintoye, 2008) " As a result of this diversity, there are materials, components, services and subsystems within the construction sector (Raja and Fernandes 2003 in Ye et al., 2009). Additionally "each organization has its own characteristic disposition" (Chinyio and Akintoye, 2008), "great variety of interests, concerns, requirements" (Zhao and Reisman, 1992). "Therefore, the interactions between diverse organizations in a project pose a high potential for conflicting stakes" (Chinyio and Akintoye, 2008) but also opportunities (Ye et al., 2009) and thus various pressures, drivers and obstacles to introduce change. "As a construction project is often the biggest single undertaking for individuals, companies, utilities or governments, there may be a reluctance to take risks as the consequences of losing out

financially if things go wrong will far outweigh any possible advantage from an innovative technique" (Davey-Wilson, 2001).

### 3.5. Sustainability transitions

The complex and interdependent composition of the urban environment means that it can usefully be considered a *socio technical system*. A socio-technical system is a system comprising of individual actors and their networks, institutions with their cultures, norms, regulations and standards, material artefacts and knowledge (Geels, 2004). Those elements, through interaction with each other, deliver certain services to society (Markard et al., 2012). The term was devised to provide context for changes towards sustainability. The transformations of *socio-technical systems* towards sustainability are called *sustainability transitions.* They (i) are long-term, multi-dimensional, and fundamental; (ii) lead to more sustainable modes of production and consumption (Farla et al. 2012); (iii) require not only technological advancements but also innovations in user practices and institutional (regulatory or cultural) structures.

There are various frameworks and conceptualisations of sustainability transitions (Farla et al., 2012). A literature review of 504 journal articles, named at least 17 different approaches explaining processes leading to transformation of socio-technical systems (Markard et al., 2012). Despite many differences, they agree on the following characteristics of sustainability transitions:

(i) Long timeframes of transformations.

(ii) Requirement to involve a wide range of actors.

(iii) Impacts on multiple dimensions including technological, material.

(iv) Organisational, institutional, political, economic, and socio-cultural.

(v) Resulting in new products, services, business models, policies, legislation, and organisations (Rezgui et al., 2010; Farla et al., 2012).

# CHAPTER 4 SUMMARY OF THE LITERATURE

## 4.1. Knowledge exchange

Knowledge can be both tacit and explicit; it is explicit knowledge that is incentivised for knowledge exchange. Knowledge exchange aims to encourage the user(s) to use the knowledge, and many claim that it is the tacit knowledge is required for the proper use of the explicit knowledge. The matter of use is important as, without use, there is no innovation and no impact. Movement of tacit knowledge can be ensured by:

(i) Enabling the user to observe the use of knowledge.

(ii) Enabling the user to learn by doing, and to receive feedback.

(iii) Facilitating and giving feedback on the use of knowledge to practitioners.

In the absence of the above, the evidence of demonstrated proper use of the knowledge that was intended to be mobilised by the target audience, can prove that the tacit knowledge has moved and has been developed in-situ. The Davenport and Prusak (1997) suggest a framework with fife stages, where the three initial stages involve theoretical engagement with the knowledge (listening, discussing, defending), and the two later stages are: teaching and performing the knowledge in practice (Davenport and Prusak, 1997). The last two are believed to be more likely to engage and develop tacit knowledge than only discussing it with peers.

The knowledge of the research cycle consisting of design, data collection, analysis, testing, and dissemination, provides an accessible mechanism with which to assess whether there has been the opportunity for participants to develop any of the skills involved. In judging this, practical involvement in scoping, testing and analysing would be considered more complex, and requiring tacit knowledge. By contrast, data collection, which can be mechanical, and dissemination, that can be repetitive would not signal the movement of tacit knowledge.

Knowledge can be learned and used by practitioners self-engaging with the knowledge, provided enough information is available and other contextual external and internal conditions are met. However, studies have shown that the process of new knowledge utilisation is more effective if facilitated – of all external factors, facilitation was the most important (Kitson, 1998).

The other factors influencing the effectiveness of KE include trust (Park and Le, 2014; Santoro and Saparito, 2003; Nutely et al., 2007). Literature review provided evidence

where repeated direct interactions, as well as equity of relationships were seen as conditions leading to the trust building. The trust building is seen to lower uncertainty, and increase the willingness to risk taking. It also positively influences the long-term relationship. In addition to trust, the literature show that that equity of relationship facilitates learning amongst adults (Huberman, 1994).

From the literature on challenges to KE it can be seen that communication is essential. Jargon and lack of understanding of each other's frame of reference with regard to theory, working, professional conducts etc. has long been seen as dividing the communities into them and us – two communities (Caplan, 1979; Crishna and Przybycien, 2016). Again, the 'ivory tower' suggests dominion of the theoretical knowledge at the universities and the creation and use of jargon exacerbates the problem. It can be concluded that removing those barriers to communication would make the KE more effective.

Lastly, in knowledge exchange, the learning of practitioners is important not only for them to be able to repeatedly use of knowledge but also to adapt it to changing circumstances. This is particularly important for urban sustainability of which understanding and targets are often changing; which progressed project by project, and is linked with the development of technology, and changes in human behaviour. In addition, literature shows that contextualisation of knowledge is essential to its use; this adaptation can be facilitated by academics or undertaken by practitioners, who acquired skills and abilities to do so.

#### 4.1.1. ***Framework for assessment of engagement benefits.***

As a result, four categories of features of knowledge exchange emerge that can be linked to its effectiveness: (i) that of relationships which develop trust, (ii) jargon free communication, (iii) mobilisation of all types of knowledge, enabling learning; (iv) facilitating or witnessing utilisation of knowledge. These are theoretical assumptions, which have been summarized as *engagement benefits* can be observed directly, or approximated from other indicators which literature cites as relevant to them and which can be reported. In that:

- Development of trustful relationships can be assumed from frequency of directs interactions and relationship dynamic within.
- Jargon-free communication can be assessed by analysing of communication styles and reference made to mutual understanding of each other's frames of reference.

- Movement of all types of knowledge can be approximated from the engagement of practitioners in different stages of research and their access and engagement with the knowledge in question.
- Knowledge Utilisation and repeated use can be observed directly or by its outcomes.

The above four categories provide a foundation for a framework assessing whether knowledge exchange activities displaying the *engagement benefits* are more effective than other in making an impact.

### 4.2. Impact on urban sustainability

The framework above assumes that if the *engagement benefits* are present, the KE will be more effective in making an impact. However, there is no agreed, uncontentious definition of impact. The impact agenda defines it as a demonstrable influence of research on health, and wealth of societies, implying it can be facilitated by knowledge exchange. Evaluation studies provide a more complex illustration of how measuring impact is approached. Rather than looking for impacts on complex environments resulting directly from interventions or specific research results, they distinguish between inputs (KE communicating research results), outputs/ outcomes (instrumental and conceptual uses of research) and impact (changes resulting from that). The outputs and outcomes represent the stages that need to occur between interventions and impact (unless the outputs/outcomes are defined as the desired impacts themselves). In the context of urban sustainability, the desired impact is the improvement of the urban environment towards it becoming sustainable. Considering the complexity of urban sustainability, elsewhere in the literature referred to as a transition of a socio-technical system, an approach assuming a direct link between an intervention and a change, seem far too simplistic. It is rather expected that any change on urban sustainability may take several stages over a period of time, before any demonstrable evidence of it can be seen. However, proving causal relationships between research, knowledge exchange and changes in practice or behaviour are challenging to prove. They take place within social context and are exposed to many external factors which may prevent or support the uses of research, or be random and unrelated to research altogether. The are often also obscured to researchers, as they happen, as Boaz calls it: ‘beyond the door’ (Boaz et al., 2008). Using the analogy of ‘a door’ being the point of reception of research by practitioners, it is the researcher participation in what happens ‘behind the door’ that could reveal whether and how the research is being used in practice.

### 4.2.1. *Impact assessment framework*

A review of more than 170 impact evaluation reports of complex, multi-stakeholder projects suggested that projects were approaching impact evaluation from different perspectives. Some studies impacts on understating, knowledge and skills of practitioners, other looked at the impacts of their work on policies, regulations and commercialisation; lastly some studied the impacts of their interventions on environmental indicators, societal processes. The challenges to prove causal links between the KE interventions and those outcomes and impacts was commonly reported (Fazey et al., 2014). Some projects resorted to only to reporting on the interventions undertaken without trying to link them to tangible outcomes.

Fazey (2014) named the various areas of influence as impacts on Understanding, Change of practice and Impact of Change of Practice.

This thesis proposed to transform the categorisation of impact into a framework where impacts on those various areas can be mapped. In order to do so, the sole evidence of impacts in the respective areas are considered sufficient to record it, and causal links between impacts in the different categories is not explicitly sought. In doing so, it changes the traditional approach to impact measurement from linear pathways to recording scattered, simultaneous or subsequent changes to various interrelated areas, which are typical to socio-technical systems such as the urban environment. The subcategories of impact falling under the broad three categories of impacts are listed in Table 6.

Table 6 Categories and subcategories of impact in the proposed framework

| Understanding |
|---|
| 1. Increased knowledge, awareness or understanding<br>2. Skills: new skills learned by participants<br>3. Attitude and attitude change<br>4. Intention of behaviour change<br>5. Confidence: increased confidence in participants<br>6. Innovation: creation of innovations and new ideas<br>7. New structure: new networks or structures are set up, communication is improved<br>8. Provision of information: amount/quality of new information provided<br>9. Identification of further needs or action<br>10. Symbolic/political use of knowledge |
| Change of Practice |

| |
|---|
| 1. Individual behaviour change<br>2. Use of new technology or tool<br>3. Decisions made<br>4. New evidence integrated into policy/strategy<br>5. Change in organisational process or decision making<br>6. Creation of new institution, system or project: Includes only outcomes of KE, not the KE itself<br>7. Further sharing of knowledge<br>8. Use of knowledge |
| Impacts of practice change |
| 1. Ecological health<br>2. Social and economic welfare<br>3. Social equity/participation<br>4. Business performance<br>5. Quality of health and health care<br>6. Capacity built<br>7. Benefits for stakeholders involved |

# CHAPTER 5 METHODOLOGY

## 5.1. Philosophical consideration

Research philosophy directs their choice of research strategies and methods in line with their understanding of what knowledge is, how it is developed (Saunders 2011). The research described in this thesis falls broadly towards the subjectivist end of the ontological spectrum. Ontology explains the nature of reality, with two opposite perspectives, that of objectivism and subjectivism. The first assumes that "social entities exist in reality external to social actions concerned with their existence" (Saunders 2011). The latter argues that "social phenomena are created from the perceptions and consequent actions of those social actors concerned with their existence" (Saunders 2011).

The choice of ontology influences the selection of an epistemological perspective. Epistemology defines what constitutes acceptable knowledge and include positions such as positivism and interpretivism**"** (Saunders 2011). Positivism assumes that knowledge comes from studying entities, which are external to the researcher, can be counted, and can be studied without being influenced by the researcher. The research in this dissertation leans towards the other end of this spectrum drawing as it does from two epistemologies. The interpretivism studying the historical case study and critical realism with regards to the rest of the research. The historical case study aimed to understand the phenomena of knowledge exchange and impact from the bottom-up perspective of the individuals involved, and used ethnographic and grounded theory methods for data analysis.

The understanding that was created in this process was complemented and expanded by a literature review and led to the remaining research questions being studied through the lens of critical realism. This philosophical position posits that we come to an understanding of the social world through an understanding of structures and processes that created the phenomena that, we are being investigated (Bhaskar 1989 in Saunders 2011)). This is done through a multi-level study (e.g. at the level of the individual, the group and the organization). In this research, activities and perceptions of individuals in SUE and SUDS were studied and contextualised within organisational structures of ISSUES and the SUDS WP, taking into considering also the interactions between the different levels of individuals and organisations. The critical realist approach to an ever-changing social world fits with this research, as the purpose is to understand the reason for phenomena in order to recommend change (Saunders 2011), and aims to improve the knowledge exchange practices of academics.

## 5.2. Research approach

The approach to research was inductive at first and deductive later. The inductive stage aimed to understand and theorise on two perspectives of the same phenomena: on one hand how people approach the implementation of KE in a research project, and on the other hand, how people explain the process of successful knowledge implementation, not explicitly linked to activities called knowledge exchange. In the first case, the ultimate aim of the KE activities would be to lead to successful implementation. In the second case, such a successful implementation is studied to find out whether there is anything that could be done differently in the KE stage that would make it more likely for research to be utilised. The inductive stage identified themes common to both cases as well as differences between them. The inductive stage was studied through participant observation in the case of the ISSUES project, and interviews and observation in the case of SUDS. It made a distinction between the KE and implementation stage, often confused in the real world as well as definition of an effective knowledge exchange. This stage was parallel to a literature review that led to identification of qualities of KE practices that were likely to improve its effectiveness. Those qualities were formulated into a theoretical framework called Engagement Benefits Framework. This stage of research also proposed a method for benchmarking impacts of projects on urban environment called the KE Impact Assessment Framework. The participant observation led to publication of conference paper on the ISSUES project approach to KE (Przybycien et al., 2011). The deductive stage aimed to investigate, whether the theoretical assumptions embedded in the two frameworks could be applied to practices within the SUE project. This stage consisted of studying a selected case studies from the SUE Programme.

## 5.3. Case study as a main research strategy

Case study research was chosen as the primary research strategy. Each case study was supplemented by additional strategies. Case study is defined (Robson, 2002) as "strategy for doing research which involves an empirical investigation of a particular contemporary phenomenon which in its real life context using multiple sources of evidence". Yin (2013) distinguishes between single and multiple case studies – the multiple case studies are beneficial as they allow investigating in another case to the same phenomena. The nested case studies of SUE look at various projects who broadly work within the area of urban sustainability.

Common concerns about case studies include:

- Lack of rigour

- Limited basis for scientific generalisation,
- Result in large, convoluted reports
- Cannot directly prove causality (as being non-experimental)

## 5.4. Data Collection

### 5.4.1. *Participant observation (ISSUES)*

Participant observation is a technique mostly used in the field of ethnography to explore the ways and meanings held by specific communities towards given phenomena and to understand it from their position through immersing oneself in the context and problem solving activities (Hickson, 1974). The work of the ISSUES project coincided with changes in the research funder's approach towards knowledge exchange and a rapid development of the impact agenda in the UK. The ISSUES project witnessed and responded to those changes in the way it worked, undertook research, interpreted guidance and performed knowledge exchange. Participation in this process allowed them to observe and tacitly understand and interpret the processes of knowledge exchange. Participant observation was not utilized from the beginning of the researcher's involvement in the project, as her research focus was on knowledge exchange in the SUE consortia. Over time, it became apparent that working with SUE consortia provided a diverse but also very fragmented picture of KE whereas the ISSUES project approach can be studied in its own right to systematize and understand knowledge exchange processes. As a result, data collection took place in years 2009-2011.

Typical weaknesses of the participatory observation technique include:

- Access to the community that is being observed.
- Verification of the data gathered.
- The ambiguity of roles in a participant-observer situation.
- The ethics of reporting research findings (Hickson, 1974).

They have been addressed in this research in a following way. Access to the community was facilitated by a formal placement of the Thesis Author in the ISSUES project and her integration into project work. Verification of the data collected was done through discussions with the ISSUES team members and reference to literature. Ambiguity of the role in a participant-observer situation became an issue for a short period of time where the role of the researcher in the project was unclear with regard to her contribution to the project's outcomes. There were no ethical concerns with regard to reporting of the

research findings. It was negotiated with the project manager in the process of writing up the results for a conference publication (attached in appendices).

### 5.4.2. *Desk based research (SUDS)*

The initial desk-based research produced a critical events table, which outlined milestones of SUDS development in Scotland. These included:

- passing of legislation, (Bill becomes an act when approved
- introduction of policies, (objectives of government, methods and principles of achieving them, may require new law – bills or acts)
- publication of manuals,
- major events

### 5.4.3. *Interviews (SUDS)*

Based on **recommendations** of senior researchers the main SUDS stakeholders were identified. Two individuals were approached and interviewed using an open-question interview schedule. The first two introductory interviews, which were recorded and transcribed, were each 2 hours long. The knowledge from these interviews was instrumental for the understanding of the SUDS history. It both confirmed and corrected factual data gathered via online search and helped select the critical milestones in the implementation of SUDS.

Further interviewees were selected based on a snowballing technique (recommendations from the previous interviewees). Two interviewees were selected following attendance at SUDS events. All together twelve individuals were interviewed using semi-structured interviews with an average interview length of 40 minutes. Some interviews were conducted over the phone and others were in person. All interviews were recorded and transcribed. Interview consents was solicited in writing or recorded prior to the interviews.

The interviewing technique allowed capturing personal experiences of individuals, their motivations and understanding of what happened with SUDS. However, it depended on people's memory of events that took place in the past, their willingness to disclose relevant information and their personal judgement of their importance. In case of the SUDS story, personal accounts provided insights specific to particular perspectives, e.g. a water company's or a practicing architect's. Due to the large number of stakeholders involved in the agenda, only a limited number of them could be interviewed. Hence, interviews provided a fragmented picture of the process.

### 5.4.4. *Meeting records (SUDS)*

A more uniform, but less rich data was collected about the efforts of the SUDS Working Party. This was a formal group of stakeholders pursuing SUDS agenda in Scotland throughout the last 20 years. Minutes from the meetings of the group were requested and access was granted to 46 documents from March 2001 up until June 2014 on condition that no names would be disclosed.

The records of meetings as a research data have strengths and weaknesses. The most important benefits from analysing meeting's minutes comes from the fact that they capture developments taking place over many years, often noting specific areas of activity under separate headings allowing for easy tracking of their progress. The records of the SUDS Working Party covered a period of 14 years, referred to many major SUDS developments, and described activities led or supported by the SUDS Working Party. The most apparent weaknesses of the meeting's records are inherent in this type of material. Minutes are a summary of the topics discussed and subsequently approved by all participants. They are therefore unlikely to record any controversial views or attitudes in respect to any events or other organisations. They also conform to certain length and style. Moreover, the process of note-taking at the meetings is by nature factual, selective and superficial, with many potential omissions. Frequently, motivations and reasons for individual's attitudes and nuances of conversations are not recorded.

### 5.4.5. *Events' attendance (SUDS)*

In addition to the data collection methods described above, research involved attending two SUDS events in 2011. One in Watford focussed on SUDS implementation in the England and Wales and one in Edinburgh related to SUDS for Roads. They provided an opportunity to witness and discuss with practitioners the issues related to the SUDS implementation in Scotland and the rest of the UK. Notes, recordings and power point presentations from the events were further analysed. Subsequently two interviewees were identified and interviewed over the phone.

### 5.4.6. *Summary of data sources (SUDS and SUE)*

Table 7 Data sources for SUDS

| SUDS data |
|---|

| |
|---|
| - 12 interviews<br>- SUDS WP minutes (2001-2014- 56 records)<br>- Practitioners' events (Waterford and Edinburgh)<br>- Academic and professional literature<br>- SUDS legislation documents |

Table 8 Data sources for SUE

| ISSUES project's data |
|---|
| - Research notes<br>- Outputs tracking and monitoring records<br>- Reports and publications<br>- PowerPoint presentations<br>- Event records including: 16 April 2008: a) "The Ebbsfleet Challenge Event"; b) May 2009: "SUE Exchange", c) Sept 2009: "Brave New City" in Edinburgh; d) Mar 2010: "Brave New City" in London; e)Sept 2010: Inter-disciplinary work in Cambridge, f) Feb 2011: "Impact 360"<br>- video recording from events<br>- Notes from other relevant conferences: a) Scotland Knowledge Exchange Conferences (2x), b) 2010 - Innovation though Knowledge Transfer conference in Coventry, c) 2010 - IEMA conference in Manchester |
| SUE case studies' data (IDCOP, AUNT SUE, Sustainable Eastside) |
| - SUE Outputs data,<br>- meeting records,<br>- interview and emails conversation records,<br>- ISSUES case studies,<br>- SUE events' records,<br>- SUE Publications |

## 5.5. Selection of case studies

### 5.5.1. *Selection criteria for SUDS*

A case study of Sustainable Urban Drainage Systems (SUDS) was chosen to explore processes that led to its embedment in the built environment. It was selected due to following reasons:

- Displays characteristics of sustainable innovation
- It shows progress over time- has enough history to give longer perspective
- It illustrates the complexity of the built environment

- The innovation and the process are relatively contained despite being multi-stakeholder and multi-disciplinary
- Key stakeholders are local and accessible – accessibility
- The case was recommended by the senior research staff involved in the ISSUES project due to their past affiliation to SUDS projects

Looks at global perspective as well as individual milestones and their interaction

The study of SUDS explored strategies, initiatives and channels, used by individual actors as well as a collective of professionals, that were aimed at progressing the SUDS agenda in the water sector in Scotland. It investigated the implementation pathways and tried to answer questions of whether and how they made an impact on urban sustainability. The results of the study are not to be generalised, as previous research confirmed that sustainability transitions in the built environment are unique to their political, economic, cultural and institutional context (Cooper and Symes, 2008). Instead, it aimed to identify a range of possible scenarios where efforts of the actors could be associated with subsequent impacts on urban sustainability.

### 5.5.2. *Selection criteria for SUE*

The Towards Sustainable Urban Environments Programme further referred to as SUE was funded by EPSRC (Engineering and Physical Sciences Research Council) and comprised 24 research projects, both large multi stakeholder consortia and smaller scoping studies across the UK between 2002 and 2012 (Figure 3). They were funded in separate funding streams resulting in SUE1, SUE2, and SUE3. In addition, EPSRC funded SUE+, which consisted of a few related research projects, set up prior to the rest of the SUE and included in the programme at the later date. The SUE research addressed various aspects of urban sustainability spanning waste, water, pollution, energy, buildings and urban form as well as planning and design. The ISSUES project - Implementation Strategies for Sustainable Urban Environment Systems - was funded to facilitate better knowledge exchange and research uptake of the SUE consortia between 2007- 2010. The project witnessed the final stages of the SUE1 and development of SUE2 consortia, with limited interaction with SUE+ and no engagement with SUE3. This Thesis formed part of the ISSUES project. It contains the author's own analysis of SUE and ISSUES as well as references to publications of the ISSUES team.

The SUE consortia shared many characteristics, such as:

- They were large and multi-disciplinary,

- They spread across the UK,
- They linked multiple universities and external partners
- They targeted multiple audiences in the built environment.

The SUE research involved integration and negotiation of multiple perspectives, problems, data, viewpoints and agendas. It produced new understanding, new insights, new way of assessing elements of the urban environment, and new ways of making sustainability decisions. Approaches used to enable potential users benefit from this complex knowledge included embedding it in software tools, scenarios, or methodologies.

In addition to large amounts of inter-disciplinary knowledge regarding various aspects of urban sustainability, SUE also generated new skills and knowledge within the community of SUE researchers. The coexistence of social and physical sciences in the programme resulted in various levels of integration of different approaches, methodologies and epistemologies (ISSUES, 2010). As raised by one of the research groups at the final ISSUES event in London in 2011, a legacy of transdisciplinary skills and expertise gained from sustainability research should be acknowledged as a new professional skillset within the research community.

The SUE consortia covered a wide range of topics related to urban sustainability. The scope of the work undertaken by each consortium is briefly described below.

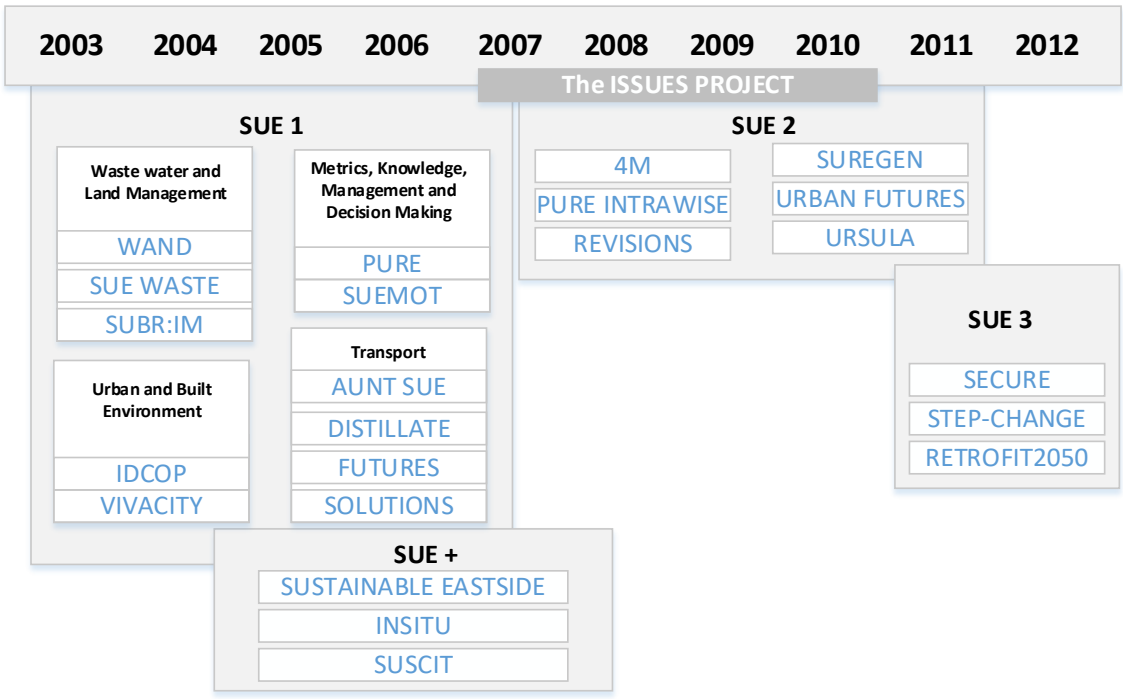


Figure 3 SUE Programme

### 5.5.3. *Selection of case studies in SUE*

As demonstrated in the section above, the SUE consortia have been pursuing different activities, predominantly focussed on the dissemination of their research findings and outputs. Responding to a survey issued by the ISSUES project requesting examples of outcomes of their efforts returned rather poor results. The difficulties to identify or evidence impact by SUE researchers might be related to factors, such as:
Insufficient time passed for research to make instrumental impact, visible change of practice or behaviour. Conceptual impact might have taken place as captured in feedback, which suggested mutual learning and raised awareness but with little or none tangible results.

The consortia that reported real-world impact included: IDCOP, AUNT SUE, URBAN FUTURES, Sustainable Eastside, PURE, SOLUTIONS. Reported stories were explored further via telephone interviews, and document analysis and the results were described in the form or reports and summary sheets. Both formats are available on the ISSUES project website[3]. The data collected by the ISSUES team in this processes were analysed with regard to the KE approaches and impacts. They were supplemented with recordings of panel discussions held at the final ISSUES event in London in 2011 that featured researchers and practitioners discussing and reflecting upon their experiences.
Based on the availability of data and types of impact stories, three projects were selected and sub-case studies were produced. They do not represent the full diversity of the engagement practices across SUE, or even within the very consortia within which they occurred. For example, IDCOP has been very active and diverse in their engagement practices, but only one example has been described as evidence was available. The vignettes mention the names of the consortia, and brief description of their research, but any other details including names and locations have been removed to ensure confidentiality.

## 5.6. Data analysis methods

Data has been analysed qualitatively, using triangulation of data from different sources. The analysis of the large volume of text data has been supported by the software: nVivo.

[3] http://www.urbansustainabilityexchange.org.uk/ISSUESSueIMPACT.html

### 5.6.1. *Triangulation*

The data was analysed using the triangulation method, drawing on evidence from sources across SUE and ISSUES. Triangulation relies on using more than one methodology to gain a fuller perspective on the subject investigated (Jick, 1979). It is believed to compensate for the weaknesses of any of the individual methods used alone (Patton, 1990). Critics of the method imply that it reveals "plurality of perspectives rather than convergence on a single 'truth' " (Moran-Ellis, 2006). Nevertheless, it provides a useful method to explore and link a fragmented and still developing landscape of knowledge exchange and engagement research and practice and it is hoped it will support the arrival at a more accurate picture of the phenomena.

### 5.6.2. *Analysing data using NVivo*

Interview records were available in a text format when transcribed, or in a format of audio files. Both formats were coded using nVivo Software. The purpose of coding was to explore the responses of interviewees and meeting records with regards to mention of knowledge exchange practices as well as understanding of triggers and impacts of certain developments. nVivo software allows analysis across various formats, including text, image, audio and video. It is used for: (i) pattern matching; (ii) explanation building; (iii) cross case synthesis, and (iv) coding and transcribing.

The SUDS case study generated large amount of qualitative data in different formats including: meeting proceedings, interviews, events recordings and documents. To support analysis of the data, the research used NVivo software, a computer tool assisting qualitative data analysis. It enables work with different formats of qualitative data, including text, images, voice and video recordings. The software does not perform analysis (Leech, 2011) but assists with recording, storing, indexing, sorting and coding qualitative data (More and Richards, 2002). It allows in a relatively short time and orderly manner to comparison of categories and codes of large amounts of qualitative data (Bazeley, 2006). The analysis undertaken with the support of NVivo follows steps and stages that can be repeated and examined at any stages of the process, while keeping track of any amendments. It is more transparent that the traditional manual qualitative data analysis techniques.

The first use of NVivo in this research was to support the transcription of interview recordings. At the same time interviews were coded for the first time. *Coding* refers to the process of selecting sections of text or audio files and assigning them to different

categories. The categories in NVivo are called *nodes*. Nodes or categories can be predetermined prior to analysis or created in the process of analysis. Coding can be done manually while data is processed (e.g. read) or it can also be automated with built-in query tools, such as *Text Search* or *Word Frequency.* Both manual coding and *Text Search* were utilized.

Initial manual coding performed on the SUDS Working Party meeting's proceedings and interviews returned multiple categories of nodes and sub-nodes.

Each node had multiple sub-nodes that were referring to specific developments. For example, the *Policy and Regulations* main node included sub-nodes referring to *PAN* (Planning Advice Notes), *Section 7 Agreement*, *SPP11* (Scottish Planning Policy 11), *SPP7* (Scottish Planning Policy 7), *Water Framework Directive* and *WEWS* (Water Environment and Water Services Act). Similarly, the *Skills and Guidelines* main node contained sub-nodes relating to manuals and training, of which manuals contained multiple further categories (sub-nodes): *Construction Stage Guidance, Design Manual, Drainage Impact Assessment, Sewers for Scotland, and SUDS for Roads*.

The initial manual coding (categorisation) identified engagement techniques including: workshops, trainings, consultations, conferences and traditional dissemination channels such as printed materials, audio-visual and online presence. These were reoccurring across all other nodes. To explore how the SUDS Working Party used those techniques, separate categories were created for each and an NVivo Query *Text search* was performed on the meeting's records. For example, for the word *workshop* the query identified all documents where it was mentioned.

The software presents the query results in three different ways: 1) listing all sources, which contained the word; 2) presenting the immediate context of the word in each source and 3) showing the entire original source with the word highlighted. In this way, it was possible to see the immediate and the wider context of the word and manoeuvre between sources and categories in the process of analysis.

Any results of the automated queries in NVivo require to be checked against any potential mistakes. The results for each of the engagement techniques had the names of stakeholders mentioned removed. They were then exported to the word document, and attached in the appendices (A-D) for reference.

# CHAPTER 6 CASE STUDY: SUSTAINABLE URBAN DRAINAGE SYSTEMS (SUDS)

## 6.1. SUDS Definition and background

SUDS stands for Sustainable Urban Drainage Systems. SEPA defined it as "a sequence of water management practices and facilities designed to drain surface water in a manner that will provide a more sustainable approach than what has been the conventional practice of routing run-off through a pipe to a watercourse" (SEPA). Since 2005, Water Environment Controlled Activities (Scotland) Regulations require SUDS to be installed in all developments which drain into the water environment, with the exception of a single dwelling or discharges to coastal waters. It took 10 years to legislate SUDS from its initial introduction to Scotland (Ashley et al., 2015; Duffy et al., 2013).

The name SUDS was developed following the introduction to Scotland of Best Management Practices (BMPs) in the early 1990's. The name BMPs was considered to be too broad and unrelated to water, hence another term was sought. The name SUDS was chosen as it described its main purpose-drainage-and it referred to sustainability and defined the context of application as urban areas. One of the people who championed SUDS recollects that changing the name initially seemed like a waste of the efforts put into promotion of BMPs, but it was later recognised as an opportunity to underpin the new term with a philosophy of the SUDS triangle (see Figure 4) , giving SUDS a distinct identity. Over the next decade, the term SUDS gained currency, appeared on dissemination materials, in academic publications, policy papers and as jargon in professional publications. Other terms emerging over time built on the SUDS concept, while expanding its scope and focus. They included *Integrated Drainage, River Basin Management*, *Water Sensitive Design*, or *Low Impact Developments".*

The previously discussed SUDS triangle is based on three principles: water quantity, water quality, biodiversity and amenity. (Figure 4)

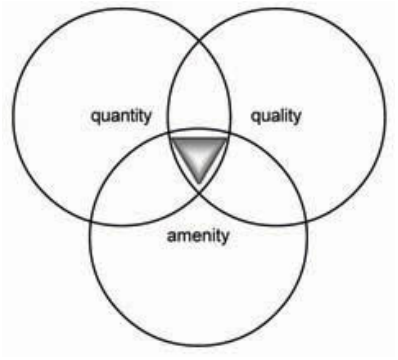


Figure 4 SUDS triangle

A Scottish SUDS champion recalled sourcing expertise from a range of people; researchers from Middlesex University regarding source control, a hydrologist from the Thames River regarding flooding and ground water recharge, and SUDS engineers from the USA and Sweden regarding technical know-how; all of whom were working on SUDS despite having different motivations for doing so, *"Playing different music but with the same instrument"*(SEPA representative). Before SUDS, separate professions dealt with those various domains (Table 9).

Table 9 Domains embraced by SUDS vs. professions

| **Domains** | **Stakeholders** |
|---|---|
| **ground water recharge** | hydrologists, |
| **distressed combined sewers** | water authorities |
| **improved biodiversity** | ecologists |
| **prevented pollution of water environment** | environmental protection |
| **increased value of properties** | developers |
| **attenuation of flooding** | local authorities and other stakeholders |

In practice, SUDS is understood in a diverse way. Some take a more broad view as described in the quote: "SUDS are a multidisciplinary approach to water management, it involves many scientific, engineering, social science fields, and it is a way of managing water environment which seeks alternatives to traditional drainage" (Industry Researcher).

Others take more narrow view and describe SUDS as a series of engineered solutions, aimed at water treatment and attenuation, such as underground storage. In Scotland, the prevailing view is that only solutions that address all three principles, of water quality,

quantity and diversity can be considered SUDS. This approach excludes underground features, as they cannot address biodiversity. In England and Wales, where SUDS use is often required in densely built areas, it is less common to use surface SUDS features, and practitioners and manufacturers of the engineered solutions (such as underground storage) refer to it as SUDS. Similarly, the main drivers and motivations to implement SUDS in the northern and the southern parts of the UK were different. Protection of water environment from pollution was the primary reason for SUDS legislation in Scotland whereas flood management is driving the ongoing legislative process in England and Wales.

The proliferation of understandings of what SUDS is and how it can be used illustrates the diversity of uses and users of SUDS. Architects, environmentalists or biodiversity experts became part of the drainage design process traditionally exclusive to civil engineers (Ashley et al., 2015). A landscape architect recollects his experience of how SUDS influenced the professional mind-set in the construction industry. He noted that before it was known, he would have been looked at awkwardly when commenting on a site's drainage design, as it was a domain reserved for civil engineers, whereas now his opinions are sought and often work is undertaken in collaboration with engineers (Interview records). However, he also admitted that his practice's expertise in SUDS is still unique amongst landscape architects, who still do not usually deal with water drainage.

### 6.1.1. *Innovativeness of SUDS*

SUDS were innovative in many different ways (Table 10). They entirely inverted the traditional drainage principles, advocating on-site surface water attenuation, rather than its rapid conveyance out of the built-up areas via underground pipe systems. It also repurposed the old engineering practice of urban drainage, developed in the 19th century, from its original objective of improving public health (Geels, 2005) to delivering wider environmental, social and economic benefits (Ashley et al., 2015). It has affected the way drainage is built, its maintenance regime and its use after completion. Traditionally, once the drainage system was built, it became a liability, requiring maintenance and serving only one goal. SUDS also require maintenance, but its purpose was to become an asset for the developments with diverse benefits to the local communities many years after completion.

Table 10 Innovativeness of SUDS

| Aspect | Traditional drainage | SUDS |
|---|---|---|
| Appearance | Out of sight out of mind (Ashley 2015). | Visible land forms and visible water. |
| Underlying principle | To rapidly convey surface and waste water out of urban areas. Drainage has only one function: that of draining | Slow down run-off and provide facilities for safe water storage in the place where it falls Drainage has more functions as summarized by the SUDS triangle. |
| Pollution treatment | Combined treatment of waste and surface water in treatment plants. | In-situ treatment of some pollutants. |
| Perception post-construction | Liability | Asset |
| Ownership status | Clearly defined by law, individual | Discussed, shared |

Typical physical representations of SUDS included swales, wetlands, ponds, retention basins, green roofs or permeable urban surfaces, some of which were invented for SUDS and other repurposed to perform SUDS. Each of the elements including design and installations required a degree of new knowledge to be generated, or an adaptation of existing knowledge leading to further innovations with regards to technology, products, professional skills and practice, regulations, building standards, and policy.

### 6.2. Factors affecting SUDS implementation

Ashley (2015) compares the contemporary struggles to implement SUDS in the UK to the 19th century resistance to the development and implementation of the first drainage systems introduced by Edwin Chadwick. He named passion and vision as the major drivers for innovation. This was confirmed by many SUDS champions, who also claimed it was exciting and fun: “It was exciting, it was challenging, we though we are breaking new ground. People liked the idea of the triangle; it was creative, multifunctional value”.

The process of breaking new ground often meant solving practical issues and changing professional habits, a process which faced a number of challenges which can be summarized under four categories (Ashley et al., 2015):

- Lack of awareness.
- High perception of risk amongst practitioners.
- Uncertainty in respect to long-term ownership and maintenance.
- Dependence on interpretation and knowledge of local authorities (move to introduction).

### 6.1. SUDS in Scotland

SUDS implementation process in Scotland was marked by the emergence of guidelines, policies, and legislation (Table 11).

Table 11 Overview of development milestones in SUDS

| | Roads /Local Authorities | Planning and Buildings | Water / Scottish Water | Environment | Other |
|---|---|---|---|---|---|
| **Earlier** | Roads (Scotland) Act 1984 | Town & Country Planning (Scotland) Act 1997 | Sewerage Scotland Act 1968 | Control of Pollution Act (CAR) 1974 | |
| **1995-97** | | | | *Environment Act '95<br>*Creation of SEPA '96<br>*Policy 15 reg. SUDS | *SUDS WP<br>*CIRIA manual 1st *DEX<br>*Scot. Universities' Monitoring Group |
| **2001** | | *PAN 61: Planning and Sustainable Urban Drainage Systems | | | |
| **2002-03** | | | *Water Environment Water Services Act | | * EU Water Framework Directive |
| **2004** | | *Building (Scot.) Reg.<br>*PAN 69: Planning and Building Standards Advice on Flooding | | | |
| **2005** | | | | *Water Environment (Controlled Activities) (Scot) Regulations | |
| **2006** | *Sustainability in the Roads Drainage System Conference | *Planning etc. (Scot.) Act<br>*PAN 79: Water & Drainage | | | |
| **2007** | | | *Sewers for Scotland'2 Ed | | CIRIA manual 2nd |
| **2008-9** | * ICUD conference | *Flood Risk Mgmt. (Scot.) Bill | | | |
| **2010** | *SUDS for Roads Guidelines<br>*Section 7 agreement | | | | *Dalmarnock Development |

### 6.2. Introduction of SUDS to Scotland

The Forth River Purification Board (FRPB) in Scotland was referred to by its contemporaries as a leader in approaches to water pollution (Interview records). A FRPB hydrologist and pollution officer assessed water quality and pollution sources across the catchment and concluded that 20% of its rivers were polluted by runoff from urban areas (FRPB, 1995). The results of this study were described in a booklet published by FRPB (FRPB, 1995). It was disseminated to regional water stakeholders, outlining how each of them, within their statutory remit, could support the efforts of managing diffused pollution. FRPB's introduction of the policy was triggered by the results of their in-house water quality research, which pointed towards new evidence regarding sources of water pollution in the catchment area. The results were considered sufficient to trigger a response in the organisation's policies. Following the merger of the River Purification Boards across Scotland into SEPA, the former director of FRBB was appointed a leader of the new organisation. One of his legacies was to introduce the aforementioned FRPB policy to the new organisation. SEPA's first internal SUDS focussed policy was introduced straight after SEPA's creation. In 2001, Policy 15 explicitly stated that Sustainable Urban Drainage was the preferred solution for the drainage of surface water run-off, including roof water, for all proposed developments (Kirk et al., 2004).

SEPA's discretionary power for legal control of surface water discharges was via the use of Prohibition Notice, derived from the Control of Pollution Act (CAR) 1974. In that, SEPA had the legal right to withhold permission for developments not adhering to the policy. On the introduction of the SUDS related policy, the organisation chose a light touch approach, in which the use of SUDS was encouraged rather than enforced by introducing a licensing system. An interviewee from the water sector, appreciated this approach and recalled: *"SEPA could have made it compulsory by refusing to allow discharge - but they did not want to go that route, they wanted to be positive: you would certainly get your consent if you used SUDS" (Water authority representative)*

Despite the light touch approach, the policy caused turmoil in the construction sector in Scotland, because stakeholders affected by the introduction of a new way of constructing drainage were not sure what to do, how to do it, and what the implication would be or the risks of taking the new approach. An interviewee recalls: *"1996-1997 all of a sudden no developments are going ahead. Water authorities are not taking new developments*

*because they do not have the design standards for them, they do not know what they are supposed to do. Developers do not want to build them, because they take-up land and they cost more and water authorities do not want to take them on. When development stalled, ministers and politicians got involved and it became a political situation"* (Scottish Water representative)

He added: "By introducing the regulation, SEPA was taking a risk because they did not know how they were going to work - but they knew SUDS would work better than if there was nothing at all"

The policy was and criteria, based on which they should grant consent to developments were new to SEPA staff. They were introduced to SUDS and the policy via formal communication and an event at which a booklet and a video were presented. The booklet was an adapted version of an earlier publication by FRPB, which explained basic information on SUDS, rebranded from Best Management Practices. The video was entitled: 'Nature's Way: a guide to surface water best management practices, the effective and economic answer to non-point source pollution'. Its main purpose was to demonstrate that SUDS was a viable and proven option for surface water management, used across the world. In addition, it was to communicate that SUDS was a measure to tackle diffused pollution and flooding and that it was endorsed by the key decision makers in the UK. SUDS champions assumed that the message could not simply come from SEPA, as the new organisation was still lacking coherence. Moreover, internal bias between the recently dissolved purification boards was affecting communication. They searched for strategic alliances, and approached the UK Environmental Agency and SUDS experts from the United States and Sweden. They also approached SEPA's newly appointed Chief Executive. The presence of the Environmental Agency and foreign experts gave the video a national and international scope. The contribution of the chief executive of SEPA gave legitimacy to create and roll out new SUDS policy.

### 6.2.1. ***SUDS Working Party***

The SUDS working party (SUDS WP) was created in 1997 in order to "oversee the implementation of the technology, resolve any disputes and address needs for successful implementation, including on-going maintenance and statutory constraints or uncertainties" (D'Arcy, 2013). It was anticipated that is would support the process of SUDS implementation for 3-5 years. At the time when the records were reviewed, in 2014, it was still active. One of its founding members described the purpose of the SUDS

WP as developing from simple problem solving, through to resolving the issues of SUDS ownership and vesting, creating guidelines, monitoring, and finally expanding into source control and engagement with the most reluctant audiences, the roads engineers. This was done, for example, by commissioning a SUDS manual that developers could use to incorporate SUDS features. The manual, in the absence of appropriate legislation, would informally regulate how stakeholders should collaborate. One of the interviewees explained that in order to change the law, the process would have to go through the Westminster Parliament, so it was considered a long-term measure, whereas creating a manual endorsed by all was what they could do faster.

The SUDS WP has been meeting regularly, 3-5 times a year. The group started with a membership of just over 10 stakeholders and over time, cumulatively more than 60 organisations[4] have participated in the meetings since its creation, either as members or as guests (Figure 5). In 2014 members included: SEPA, Scottish Water, Homes for Scotland, Landscape Institute Scotland, Royal Incorporation of Architects in Scotland (RIAS), Scottish Enterprise, Scottish Government, Heads of Planning Scotland (HOPS), and the Society of Chief Officers for Transportation in Scotland (SCOTS).

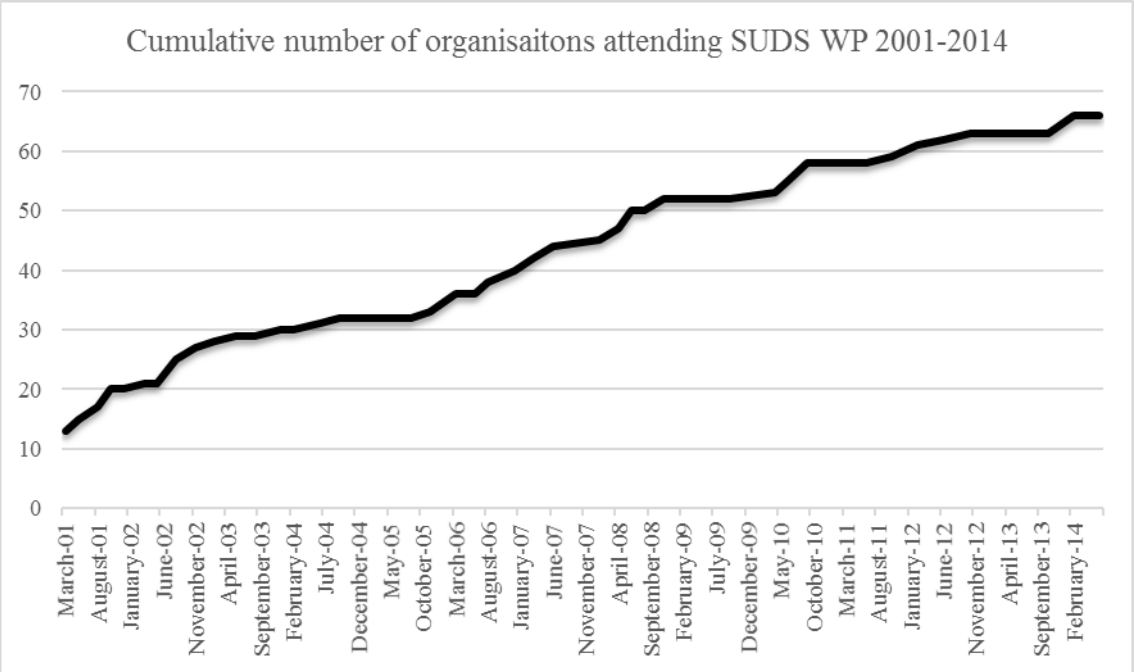


Figure 5 Organisations attending SUDS WP meetings (2001 – 2014), cumulative.

[4] See section Appendix for a full list of organisations

Analysis of the SUDS WP proceedings revealed a great diversity of topics related to SUDS implementation process that were discussed. The areas covered were in regard to one or more aspects of SUDS (pollution, flooding and biodiversity, amenity):

- SUDS technologies,
- Policy, legislation and regulations
- Local and global issues and challenges to implementation,
- Stakeholders' engagement and dissemination,
- Skills and guidance development
- Manuals and technical standards

The SUDS working party's main tools enabling tackling these issues included those which would fall under the definition of knowledge exchange and dissemination practices. These included: conferences, training, workshops, consultations, awareness raising and promotion using printed, audio-visual and on-line materials. They targeted the wider community of practitioners as well as management and employees of the organisations represented in the Working Party.

### 6.3. First large scale development: Dunfermline Expansion Side

The Dunfermline Expansion Area (DEX) was an example of a first large scale development that implemented integrated SUDS design in Scotland. The decision to implement SUDS was a result of the development being refused consent for discharge via conventional drainage solutions; a consequence of introduction of SEPA Policy 15. The site was 5km$^2$ and was located to the east of Dunfermline. It was bound by the M90 motorway on the eastern boundary and by the town to the west (see Fig. 6). It was identified as a development area which could only go ahead if a solution was found that would allow mitigating against significant flood risks posed by four local watercourses (D'Arcy and Robin, 2007). In addition, for SEPA, it was also a chance to address water pollution, as the local watercourses were known to SEPA for their low water quality.

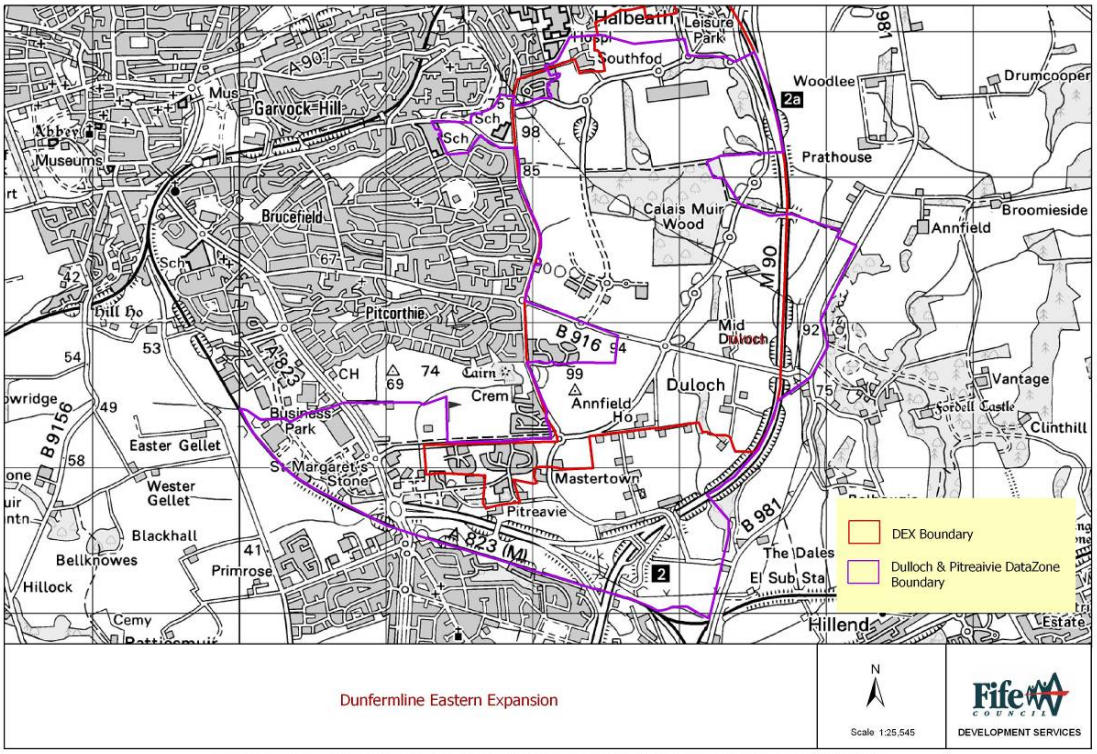


Figure 6 Dunfermline Expansion Site (Darcy, 20070

The Pollution Prevention Officer recalled that it became apparent that a lack of know-how and experience in designing SUDS was a major challenge for developers, who, despite requirements for SUDS, were suggesting conventional drainage designs. DEX stakeholders created a steering group tasked with finding solutions. In the absence of local guidelines or standards, the group sourced expertise from abroad, as SUDS has had a longer history of implementation in the USA and some European Countries, under the name of Best Management Practices (BMPs). A SUDS expert from Florida was commissioned to run several workshops with the stakeholders involved in the DEX development. The workshops focussed on the technical aspects of SUDS implementation, including how SUDS work, how to construct them, and how to oversee the design and construction of the integrated approach on-site.

Despite having access to expertise, technical know-how underpinned by experience, and evidence on the SUDS performance there was still a degree of resistance and uncertainty amongst stakeholders, especially developers and engineers. In 1997, a Conference of the American Society of Civil Engineers took place in Malmo and a group of stakeholders from Scotland, including those involved in DEX, were invited to attend. To ensure their attendance, funds were found to cover costs, resulting in the participation of six people from Scotland. Amongst them were: a lead DEX developer, two employees of water

authorities, and a SEPA staff member. The conference was a turning point for participants, especially for the developer, who became the SUDS champion in the DEX project. The number of people who attended the conference was referred to as a sufficient critical mass that enabled the SUDS agenda to be moved forward in DEX -and further afield in Scotland. Factors mentioned to have influenced the attitudes of the attendees in favour of SUDS included:

- The overwhelming presence of external, unbiased evidence, regarding performance of SUDS features from across the world.
- Examples of sites with monitoring data going back many years.
- The ability to see the SUDS features in the ground.
- The opportunity to talk to local engineers, water authorities and other stakeholders working on SUDS.
- The human aspect of the conference where attendees had a chance to get to know each other, build trust and friendly relationships, and jointly experience a conference abroad.

An interviewee highlighted the importance of the exposure to vast amounts of information, proving that SUDS was widely researched and implemented across the world. He also rejected the suggestion that jargon or complexity of information presented at the conference was having a negative influence on the understanding of practitioners: *"Imagine everyone's talking of nothing else than SUDS. After a week of all that it's becoming completely normal for all"* (SEPA representative).

A water authority participant explained how learning about SUDS use on the scale of a city such as Malmo, made it apparent to water companies how they could use it to de-stress their combined sewers: *"The Malmo city engineer imposed SUDS on new developments. He was able to offer the customers an incentive to disconnect surface water from the overloaded combined sewer and he was successful with that. He did not have to replace the sewer. And I think the water authority people who attended understood how SUDS can be part of a toolbox. We were now thinking this is part of a toolbox for running and urban drainage system - as well as to protect the environment from new urban drainage".* (Scottish Water representative)

Despite the many benefits of a collaborative decision making process, the DEX steering group's effectiveness was challenged by the multiplicity of perspectives and priorities

represented, which led to many compromises regarding SUDS installation in DEX. *"There are many things we could do differently now, but to get all of the stakeholders in the room and get them to talk and agree was difficult, it was tricky. The roads department would not turn up and everybody would disagree at some point but because they wanted to develop the site, and there was underlying financial reasons to do that, we managed to reach agreement"* (SEPA representative).

### 6.4. Scottish Universities Monitoring Group

The DEX development provided opportunities for the generation of SUDS performance data. Responding to the SUDS Working Party suggestion to Scottish universities that they should collaborate and bid for research jointly, the "Scottish Universities' Monitoring Group" was set up in 1997. It included Universities of Abertay, Aberdeen, Heriot-Watt, Edinburgh and Stirling. The research was commissioned through the SUDS WP, though funding came from various stakeholders, including SNIFFER, SEPA, the Environment Agency, Wilcon Homes, Scottish Water, and the Carnegie Trust (SNIFFER, 2004)

Students from the Environmental Engineering Master's courses at Abertay University and University of Edinburgh undertook a large proportion of the research. SUDS WP welcomed the involvement of Master's students as it provided a cost effective solution to their research needs. A Master's student would typically concentrate on monitoring a SUDS element, such as swale, a filter trench or a pond. A lead academic from Abertay University recalled the importance of the research undertaken by students: *"The student projects were tracing SUDS performance, convincing society at large that these things work"* (SUDS researcher)

The monitoring data from DEX and beyond were supporting decision-making about SUDS. A report by (Scotland and Northern Ireland Forum for Environmental Research) SNIFFER referred to the monitoring results informing the SUDS design guides through information on treatment volumes, percentage runoff, and changes in water qualities, inlet and outlet designs (SNIFFER, 2004).

The involvement of students in the monitoring of SUDS, who could see the use of their work in the monitoring of SUDS, educated and inspired a cohort of professionals who went to work in the private and public sectors upon completion of their studies and further promoted SUDS. One stated: *"It was a good approach [to involve students]. We knew*

*we were in that for a long time and we were looking for the endemic change so the role of students was essential*" (SUDS researcher).

### 6.5. SUDS Manual

The development of the SUDS manual coincided with the DEX site construction, providing an opportunity for all to learn about SUDS theoretically and see it implemented in practice. The SUDS Working Party commissioned a UK based company, Construction Industry Research and Innovation Association (CIRIA), with the production of the manual. The SUDS WP decided to reach out outside their own organisation despite having access to industry representatives, an exemplar site, and SUDS experts who could produce the manual locally because it was perceived was perceived that CIRIA had a UK-wide industry buy-in as a reliable, practitioners-focussed information source. CIRIA was also already associated with championing source control at the UK level. SUDS WP hoped this would add credibility, objectivity and status to the new SUDS Manual in Scotland and beyond, and mitigate the potential bias that stakeholders in Scotland might have had towards SEPA or the SUDS WP.

CIRIA formed an industry steering group, engaged SUDS experts working on DEX, and consulted members of the SUDS WP. In 2000, they produced the "Sustainable urban drainage systems - design manual for Scotland and Northern Ireland" (C521)[5].

The manual in its final form did not satisfy all stakeholders in the SUDS WP. The main reason for this was that it lacked specificity with regard to many technical aspects and stakeholders' responsibilities. A member of the SUDS Working Party explained the challenges of reaching consensus amongst multiple stakeholders in the process of the manual production: *"The first CIRIA manual did not go far enough, but it probably went as far as it could at that moment, as there were people at different stages of agreement. So I came from the site of habitat and I was really wanting to tell people how to put ponds in and what ecological target they should be aiming for but this is very difficult to achieve"*(SEPA representative)

A Scottish Water representative explained that the vision for the manual was to agree on the major principles of how organisations should work together to allow optimum design, construction and maintenance of SUDS. This objective was broadly achieved and the

[5] This document is no longer current but it is cited in the building regulations for Scotland. It was superseded by C697 SUDS manual (CIRIA 2007, reprinted 2011)

first CIRIA manual was released in March 2000 with a very general specification of the maintenance responsibilities for SUDS. However, its implications in practice were interrupted by the introduction of a new relevant legislation passed by the newly established Scottish Parliament, which redefined those relationships and responsibilities again.

This can be illustrated by the example from the Section 7 Agreement. The Section 7 of the Sewerage (Scotland) Act allowed local authorities and water authorities to enter into agreement over shared drainage. The agreement existed prior to the organisational change but it was not used as it concerned parts of the same organisation. It became an issue with the splitting up of the two and the emergence of the SUDS agenda. The arrangement suggested by the Sewerage Act was to divide the maintenance of drainage according to above ground and below ground rule, whereby water authorities would be responsible for below ground drainage and local authorities for the above ground features. This required agreements to be made between the two authorities on a project-to-project basis. A streamlining of the process by devising a model agreement based on the above-mentioned rule was being negotiated along the lines suggested in the SUDS manual. A Scottish Water representative recollects that the arrangements and negotiations were very close to being finalised. However, at the same time, the Scottish Parliament was established, and this opened an opportunity to update the existing legislation and to define the legal responsibility for SUDS maintenance. At that point, as the interviewee recollects, the water authorities retreated from all arrangements made with local authorities regarding shared responsibility for fear that this might provide an excuse for the legislator to cede all the maintenance responsibilities to them.

During the 7 years following the introduction of WEWS legislation, the new Water Authority was developing its SUDS-embracing technical guidelines ('Sewers for Scotland 2'). During that time it also continued negotiations with the local authorities and SCOTS (Society of Chief Officers of Transportation in Scotland), the road authority, regarding templates for Section 7 Agreement. In 2007, Scottish Water consulted all Local Authorities and SCOTS about the proposed wording of the agreement. Following that amendments were made, but the concerns of Local Authorities (LA) and SCOTS regarding maintenance costs remained. In 2009, stakeholders of a large development in Glasgow successfully agreed to enter into agreement using the Section 7 Agreement. This was considered an important milestone which led, in 2010, to the release of an agreement

template. The agreement was broadly following the above-below ground rule originally anticipated in the CIRIA manual. The Scottish Water representative's reflection is revealing: *"Personally, I wish we would have gone with the above and below ground agreements in 2000. I think we would have learned more by actually doing SUDS than the time we spent changing legislation and putting the design manual in place. What we now have is a large legacy SUDS that have not been adopted - all the developments that have been built and are in limbo".*

### 6.6. WEWS Act and Sewers for Scotland 2

The re-establishment of the Scottish Parliament in 1998 significantly changed the outlook for SUDS legislation. SEPA and the SUDS Working Party were lobbying to enshrine SUDS into law. The European Water Framework Directive (WDF) added urgency to the cause. In the process of transposing WDF into Scottish Law, the new Water Environment and Water Services (Scotland) (WEWS) Act was passed in 2002, which amended the Sewerage (Scotland) Act 1968. As a result, SUDS was included in the definition of drainage. Through that change, public SUDS gained the same legal status as conventional sewers and the scope of the water authority to adopt and maintain public SUDS was defined. At the same time, the three water companies amalgamated into one: Scottish Water.

The WEWS's role in defining SUDS ownership effectively gave one of the stakeholder organisations the legal right to use their budget on SUDS maintenance. At the same time, it meant that SUDS had to comply with the design standards of Scottish Water as the other drainage systems. The CIRIA manual could not fulfil this requirement, as it was not specific enough. An interviewee explained: *"If we were to adopt SUDS we needed to know what their value were and the cost to adopt, performance and whole life costing"* (Scottish Water representative).

The production of 'Sewers for Scotland 2' was preceded by research sponsored by Water Industry Research in UK (WIR). The research involved the monitoring of a series of mature BMPs/SUDS sites both in the UK and in the USA. Many researchers previously working on DEX design and monitoring, or those engaged in production of the SUDS manual, contributed.

Three workshops with main stakeholders groups (SEPA, LAs, Road Authorities) and a written consultation with practitioners in the industry, fed into the final version that was released in 2007[6].

'Sewers for Scotland 2' design standards required that the construction work on developments needed to be completed in 95% before Scottish Water could vest SUDS features. Since the standards were available from 2007, a large number of SUDS features built beforehand could not have complied with those requirements and have not been adopted by Scottish Water. At the time of the interview at Scottish Water, there was not a clear strategy for dealing with that legacy.

Implementation of WEWS legislation affected Controlled Activities Regulations, which were updated in 2005 to explicitly mention SUDS as a mechanism to be used for the prevention of pollution to the water environment.

### 6.7. Last adopters of SUDS

The impervious surfaces associated with roads, including pavements, driveways and car parks could often cover up to 70% of the total impervious areas in urban areas (Wong, 2000). Although the Roads Authorities were not responsible for all of them, their role cannot be underestimated. However, roads authorities were the most reluctant party in endorsing SUDS in their practice in Scotland. There was a perception that SUDS were not suitable or were unsafe for the construction of roads despite evidence of its successful application elsewhere. The SUDS champions suggested that the reasons for this reluctance was a simple lack of interest and incentive. They also gave examples of road departments actively blocking SUDS proposals for developments in some local authorities as reported at the SUDS WP meetings, or simply not attending meetings where decisions about SUDS were to be taken.

#### 6.7.1. *Sustainability in the Roads Drainage System conference 2006*

To engage road engineers, SUDS Working Party in partnership with Homes for Scotland, organised a conference "Sustainability in the Roads Drainage System" in Edinburgh in 2006. The conference reinforced the need to produce technical guidance for road engineers. The production of the guidance was designed to account for developments in the 'Sewers for Scotland 2' and be launched together with the release of the second CIRIA manual in 2007. The engagement of SCOTS in the process was considered fundamental,

[6] Sewers for Scotland 2 was updated in 2015 (Sewers for Scotland 3) and the 4th edition is under consideration.

as well as highlighting linkages of roads guidelines with the other construction standards and legislation. SCOTS endorsed the idea and funding was sought to employ a dedicated person to work on the guidance. Commencement of the collaboration was disseminated at the Roads Expo conference, the ICUD conference (2008) and in professional magazines. In 2008, the production of the guidelines commenced through the commissioning of consultants from WSP. The consultation that took place following the launch of the guidelines in 2008 brought several recommendations with regard to the implementation strategies. These included recommendations made:

- To provide ongoing training for professionals, initially provided by Abertay University within their EU-funded SKiNT project.
- To update roads legislation.
- To issue new policy to local authorities in order to advise them how to apply SUD for Roads within the current regulatory and legislative framework. Another route to do so that was considered included the consolidation of the existing Planning Advice Notes 61, 69 and 76.
- To produce further guidance and coordinate with DEFRA.
- To seek evidence on maintenance costs.
- The last recommendation was addressed by commissioning research with regard to the whole life costs of maintaining SUDS. A spreadsheet for calculation of the whole life costs of SUDS was produced in 2012 and has since been disseminated through events alongside SUDS for Roads guidance.

The process of implementation of SUDS within the roads domain was started with the publication of the SUDS for Roads guidelines. The SCOTS have since championed the SUDS agenda.

# CHAPTER 7 DATA ANALYSIS: SUDS

## 7.1. Introduction

This chapter contains analysis, results and discussion regarding two sets of data. Sections 7.2 to 7.3.6 regard knowledge exchange practices. Sections 7.4 to 7.6.2 regard SUDS implementation processes, referred to as: *Change* of *Practice and Impact of Change of Practice*.

## 7.2. Method on knowledge exchange practice in SUDS

Mechanisms of knowledge exchange, used collectively and individually by practitioners (the majority of whom were members of the SUDS Working Party) were identified by the coding of qualitative data from interviews and meeting records (using nVivo software). The same method was used to identify characteristics of those mechanisms corresponding to the *Engagement benefits*. Evidence for practices of individuals were presented as quotations or embedded in the text of Chapter 6. The collective knowledge exchange practices used by the SUDS WP were presented in this chapter in the form of short descriptions and tables. The tables contain categories of how each KE channel was used, with each category containing references to corresponding evidence from the SUDS WP meeting minutes. The evidence attached in the Appendices of the thesis is in the format of tables containing extracts of data labelled by letters and numbers: evidence regarding "conferences" is marked as "A2"," A7", where letter A represents "conferences" and the number is the number assigned to the extract.

## 7.3. Data on knowledge exchange practice in SUDS

The implementation process of SUDS involved knowledge exchange practices taking place between individual stakeholders, organisations and groups of stakeholders

### 7.3.1. *Dissemination methods following the linear KE models*

Traditional dissemination channels aimed at awareness raising and promotion of SUDS included: reports and leaflets, posters, video, online materials and networks, manuals and guidelines, and books and academic publications (see Table 12).

The promotional materials and new SUDS guidelines were distributed by the members of the SUDS WP within their respective organisations. They were a sent directly to specific individuals on behalf of the SUDS WP.

Over time, the use of online materials increased, however printed format remained an important dissemination vehicle for the SUDS WP. SEPA's own *VIEW* magazine as well

as other magazine articles, were used to disseminate developments in SUDS. Online materials were made available on the websites of SEPA, SNIFFER and CIRIA.

Table 12 Evidence for dissemination (all formats) materials

| Title of the material | Targeted audience |
|---|---|
| SEPA SUDS booklet | SEPA employees |
| Video "Nature's Way" | all Local Authorities and Planning Departments, 500 to Directors of Planning, Scottish House Builders Association, SUDS WP members |
| Section 7 agreement template | COSLA and SCOTS |
| Sewerage for Scotland 2 | Developers and Local Authorities |
| SUDS Design Manual | Local Authorities and Heads of Planning |
| Newsletter Permeate | Directors of Planning, Scots, Homes for Scotland, ESW, SUDS WP members |
| Consultation results (Sewers for Scotland2) | all SUDS WP stakeholders and workshops participants |
| Drainage assessment (2000 printed copies) | SUDS stakeholders, Local Authorities, others |
| Construction Stage Guidelines | Head Offices of House Builders |
| Suds for Roads | all Local Authorities |
| CIRIA manual C698 | Local Authorities, CICA Contractors Association |
| SEPA's VIEW magazine | SEPA's employees |
| Online resources: SUDSdrain, CIRIA, SEPA, Scottish Water | Practitioners and general public |

### 7.3.2. *Engagement methods following the interactional models:*

Collaboration and engagement was used by practitioners at every level of SUDS development and implementation.

- **Within organisations:** evidence for collaborative efforts of employees and management within Forth River Purification Boar, SEPA, and Scottish Water.
- **Between Organisations:** evidence for collaboration in the establishment of the SUDS WP, the steering group for DEX, research projects, Scottish Universities Monitoring Group, development of CIRIA manuals, and 'Sewers for Scotland'.

- **Collective and collaborative engagement and dissemination:** evidence available in the SUDS WP minutes describing a coordinated approach to using knowledge exchange and dissemination practices across the sector. The practices were predominantly engagement based and included channels such as conferences, workshops, trainings, consultations and dissemination. Each of the channels was used to fulfil several functions:
    - Conferences (see Table 13 for evidence)

The SUDS WP used conferences for diverse purposes. Conferences were organised or attended in order to disseminate work that the SUDS WP planned, progressed or completed, as well as informing conference attendance about other SUDS developments. Conferences were viewed as sources of new information for the group. Information about upcoming conferences was promoted, with the aim to ensure and coordinate the SUDS WP representation. Presentations given at conferences by the SUDS WP members were circulated within the group. Conferences were also considered to be opportunities to learn about and to engage with new audiences, especially those resistant to change: road engineers. Involvement in conferences of senior figures from organisations represented at the SUDS WP, as well as representatives from the Scottish Government, was strategically planned depending on the prestige of the conference. International conferences gave an opportunity to approach policy makers, whereas local conferences engaged practicing engineers.

The SUDS WP decided on their level of contribution to other conferences by assessing the conferences' potential usefulness with regard to impact on policy, and dissemination in Scotland, UK and beyond.

For example, an International Conference on Urban Drainage (ICUD) 7 aimed at academics and industry alike, and organised in various locations across the world, was held in Edinburgh in 2007. It provided an opportunity for high-level dissemination of SUDS. It was identified as an upcoming opportunity for the SUDS WP to promote SUDS to the international community and senior colleagues. A sub-group was created within the SUDS WP that was tasked with organising their presence. The conference was used an as opportunity to engage with Scottish minsters and the top level management of the SUDS WP member organisations, with the aim to showcase local SUDS knowledge both

[7] http://icud2017.org/icud-conference.htm

in regard to theoretical developments and demonstration sites. The SUDS WP efforts resulted in Scottish SUDS dominating the second day of the conference, including through the uptake of pre-arranged site visits. Multiple papers authored by members of the SUDS WP were submitted and published in academic and non-academic journals and magazines. The conference was also used to undertake a survey of the conference participants with regard to SUDS for roads developments. See Table 13 for evidence on each of the above.

Table 13 Evidence for use of conferences with reference to data in Appendix A

- Members attending external conferences and providing feedback to the rest of the group (A2, A7, A14, A21).
- Submitting papers and presenting on aspects of SUDS at external conferences (A1, A5, A6, A9, A16, A23).
- Supporting the organisation of conferences by other stakeholders (A4, A22) or organising or co-organising conferences (A9, A15, A7).
- Using conferences for international/general and local/targeted dissemination
- Using conferences as a measure of SUDS uptake in the industry, and an opportunity for evaluation of public opinion.
- Coordination with other SUDS developments.

- Workshops

The workshops provided an informal opportunity for discussion, exchange of information, questions, and feedback within small groups. They were voluntary and often organised to debate a new solution being proposed. Therefore, they most likely attracted practitioners who already knew about SUDS and sought to explore the topic further. If taking part at conferences, they served to disseminate recent developments to other stakeholders. If forming part of consultation, as in the case of Sewers for Scotland, they were a platform to explore different views and feed into further development of the subject discussed. Workshops were used as a measure of engaging practitioners, and improving know-how amongst them, and raising SUDS prestige and profile. See Table 14 for evidence of the uses.

Table 14 Evidence for workshops with reference data in Appendix B

Engaging practitioners

- Engage targeted professionals (planners: B.1, B.2,) in the process of scoping (B.22), development / consultation (B.5), or evaluation of SUDS

implementation (B.24), guidelines (B.20) or policies (e.g. Sewers for Scotland 2: B.4, B.5, B.6, B.7, B.11)
- Get buy-in from specific groups, e.g. road engineers (B.10, B.11)
- Provide informal opportunities to meet between stakeholders e.g. developers and Scottish Water (B.15), Surface Water Management groups members (B.19)
- Seek organisational views and perspectives e.g. CoSLA, SCOTS, Scottish Government, Scottish Water
- Negotiate conflicting perspectives with opposing sides (Scottish Water and Local Authorities)
- Discuss problems with high profile stakeholders e.g. workshop with Scottish Government regarding adoption and maintenance of SUDS (B.24)
- Focus on development of specific areas of SUDS, e.g. Sewers for Scotland technical standards (B.4, B.5, B.6, B.7, B.11), SUDS for small developments (B.13, B.15), SUDS for Industrial Estates (B.17), Source Control (B.20, B.22)
- Maintaining engagement (B.6, B.7)

Awareness and prestige
- Disseminate new information and update knowledge of professionals in e.g. building control, roads and planners departments (B.12, B.16)
- Promote SUDS also internationally (B.3)

Know-how
- Complement new guidance (B.20)

- Training

The delivery of a formal training was not within the scope of the SUDS WP. The group was aware of how the skills and knowledge of professionals could progress or hinder SUDS implementation. Lack of skills or misinterpretation of SUDS principles were frequently discussed in relations to problems with SUDS. The SUDS WP training efforts concentrated on the employees of the member organisations.

There were two occasions where the SUDS WP commitment and interest in training provision were discussed in more detail. This was with regard to SUDS inspectors' training and the training for roads engineers and local authorities. The latter was addressed by involvement of Abertay University in a European funded project called Skills Integration and New Technologies (SKINT). Plans to continue the training were

discussed but not finalised (or recorded) at the time the minutes were reviewed. See Table 15 for evidence of the uses.

Table 15 Evidence for training with reference to data in Appendix C

| Know-how |
| --- |
| - Audiences: staff members of organisations forming part of SUDS WP (C.1, C.5), and external (C.4); professionals e.g. planners, road engineers (C.8), SUDS providers, designers, and installers (C.15), inspectors (C.17, C.18)<br>- Method and format of training: physical meetings (C.1), online materials (C.8) training update for local authorities (C.14), through professional bodies (C.13)<br>- Purpose of training: to enable change in procedures (C.10), to prevent poor performance of SUDS (C.15)<br>- Training provider: initial training developed in-house by SEPA and adapted for other organisations (C.1, C.2, C.3, C.4, C.5), training designed by Abertay University (C.8, C.9) and training provision inconclusively thought to be the responsibility of the Scottish Government, universities, private companies or professional bodies. |

- Consultations

The consultation was a method of engagement with audiences, composed of actors who would be affected by, or would be deciding upon, changes to legislation. The overarching aim was to get or provide feedback, win their support, inform, and influence them. The SUDS WP was making efforts to coordinate consultations issues with various members of the group to avoid overlaps but to benefit from synergies. Publishing consultations were described as a vehicle for issuing draft standards e.g. Sewers for Scotland 2 (D.24). The coordination with other policy and regulatory development was observed (D.21, D.22). See Table 16 for evidence of the uses.

Table 16 Evidence for consultations with reference data in Appendix D

| Engagement |
| --- |
| - Responded collectively or individually to formal consultations (Business Parks PAN (D.1), Diffuse Pollution Regulations (Controlled Activities) (D.15, D.19), Surface Water Risk Management Paper (D.38), Water Framework Directive (D.5, D.6, D.7), Water Services Bill (D.2, D.4), Flooding Bill (D.31, D.32), DEFRA (D.42), Property Factors (Scotland) Act (D.39, D.41), SCOTS National Roads Development Guide (D.45), NPPG7 (D.8)<br>- Run their own consultations as SUDS WP e.g. Drainage Impact Assessment (D.9, |

D.10), SUDS for Roads (D.34, D.35, D.36), as individual institutions : Scottish Water consultations for Sewers for Scotland (D.20, D.21, D.27), or jointly with Scottish Executive, e.g. Building Regulations (D.11)

### 7.4. Discussion: Knowledge exchange practices in SUDS

In the process of introduction and implementation of SUDS, the organisations involved used a combination of practices, which could be referred to as channels of Knowledge Exchange. The approaches corresponded with what the literature refers to as interactional and linear knowledge exchange models. Evidence suggests that where linear dissemination models were used, two major challenges were faced: (i) lack of compliance with the new knowledge, and (ii) misinterpretation and improper use of the knowledge. Interactional models were used to overcome those challenges by building the awareness, motivation and skillset of practitioners. Stakeholder engagement was present at all stages and aspects of SUDS development and implementation, including the development of standards, guidelines, legislation, policies. Engagement techniques were used with individuals or groups to negotiate, consult, and secure approval and support for SUDS. Dissemination was done using printed and online materials as well as engagement with practitioners via meetings, workshops, trainings, and conferences. In doing so, the full spectrum of KE channels and approaches were used during the period of 15 years.

The engagement activities displayed several features and properties identified in the literature as *engagement benefits*, and believed to support effective knowledge exchange.

#### 7.4.1. ***Building trustful relationship***

The subject of trust and trustful professional relationships is referred to in the data as a factor that motivated participants, lowered uncertainty, their perception of risk, and triggered action. It was particularly important in the early stages of the introduction of SUDS to FRPB, SEPA and DEX, where decisions whether and how to use SUDS were considered innovative and risky. Individuals involved in SUDS introduction to SEPA, the SUDS WP, and DEX, referred to trust, friendship, collaboration, and the excitement of breaking new ground, as shared within their collaboration and being an important, facilitating features of the process. The dissemination channels such as the *Natures' Way* video solicited the participation of external individuals who lent it their credibility and prestige; practice aimed at instilling trust towards SUDS amongst the viewers.

Stakeholders involved in the development of the CIRIA Manual, which was aimed at defining the responsibilities towards SUDS and regulating relationships between stakeholders in the absence of legislation, referred to trust building as a necessary element enabling progress, as well as its by-product. The collaborative and mutually endorsing approach was perceived essential for reasons summarised by the quotation: *"Nothing could have been achieved without the buy in of the local authorities, roads, planning and the water authorities because they had all the problems and challenges of making it happen and then looking after it once it was on the ground"* (SEPA representative).

### 7.4.2. ***Need for local contextualisation of SUDS***

At the time of SUDS introduction to Scotland, its basic implementation techniques and technologies were known, tested and proven to work under the names of
Best Management Practices in the USA, Sweden and other European countries. Despite that, in Scotland SUDS was new, and perceived to be risky and potentially unsuitable for the local environment and weather conditions. Adaptation and contextualisation of SUDS were undertaken by the following practices.

- External expert-led implementation of SUDS in Scotland with attention to the local requirements (environmental, technical and professional).
- Research and monitoring undertaken by Scottish universities and professional consultancies with regards to DEX or the CIRIA Manual provided evidence on the performance of SUDS.
- The method of trial and error were commonly practiced.

In addition, the process of SUDS contextualisation was repeated by every stakeholder in the process of SUDS adoption to address the specific organisational requirements:

- In the process of the production of 'Sewers for Scotland 2', research and monitoring of SUDS features were undertaken by experts contracted by Scottish Water, despite the fact that many aspects of the knowledge already having been studied and been made available in the CIRIA manual.
- In the process of the development of SUDS for Road guidelines, further analysis and contextualisation of SUDS was undertaken to make it relevant to materials and construction methods used by roads engineers and to comply with roads regulations.

### 7.4.3. *SUDS development and implementation was assisted by learning processes and skills development on all levels and involving all stakeholders*

Collective and individual process of "Learning by doing" by was prevalent throughout the process of SUDS implementation. Many solutions were introduced temporarily, and were replaced by their new versions, following the development of technology and understanding of SUDS. For example, in the area of policy and regulations, 'Sewers for Scotland 2' was replaced by 'Sewers for Scotland 3'; 'CIRIA Manual 1' was updated by 'CIRIA manual 2'. For practitioners involved in construction projects, the practice of creatively seeking solutions and learning on the job was a common experience. Practitioners' choice to use SUDS, especially before its embedment in law, was driven by challenges to deliver project in a conventional way; their environmental consciousness, ambition; or their clients' requests. Practitioners reached out to industry guidelines and professional standards, and in their absence, they reached most commonly to experience of other colleagues or practitioners; case studies in professional literature. The expertise was built gradually by learning from and copying others. One's own interpretation and the evaluation of solutions chosen and implemented, led to improvements of one's own future practices on a project-by-project basis (case of individual practitioners as well as large projects). Working on the DEX exemplar site, in the process of its design, construction or monitoring was referred to as experience that shaped knowledge and professional careers of many current SUDS champions. *"There was a sense that everyone's understanding increased at the same time - from very low knowledge base to leading the way really"*(SEPA representative).

At the early stages of SUDS implementation, practical expertise was sourced externally. International experts led the implementation of SUDS features in the DEX exemplar site, as well as delivered technical workshops to practitioners. Study visits abroad were also used to increase knowledge of practitioners.

The creation of knowledge and understanding of SUDS was supported throughout by individual academics and research projects. The formal and informal partnerships with universities resulted in original scoping of the SUDS principles, SUDS performance indicators and measures, invention of technological solutions, trained students and professionals, contribution to development of technical guidelines and raised profile of SUDS.

### 7.4.4. *Flexibility of SUDS*

SEPA's early policies encouraged implementation of any kind of SUDS leaving developers flexibility. Much effort was given to the process of defining of its features and technical guidelines, but they were kept broad so as to remain inclusive.

The broad scope of SUDS and flexibility to interpret and choose SUDS features according to local requirements and technical abilities meant that it was easier to roll-out, and could be embraced by different professions. However, it also meant that misinterpreted or mal functioning systems were built, as reported by SUDS WP. In addition, technical solutions, which do not provide the full spectrum of SUDS benefits are commercialised under the name of SUDS. The industry view, however, suggests that the flexible approach taken by SEPA-although having its negative implications- was more impactful on urban sustainability than the more restrictive approach to the installation of SUDS, taken by Scottish Water. The first one allowed faster implementation of sometimes imperfect SUDS, the latter delayed the roll out of SUDS by 7 years and resulted in a legacy of unvested developments built during that time.

### 7.4.5. *Use of SUDS*

The confidence and motivation underpinning actions of the management of FRPB (then SEPA) and leading to inclusion of SUDS in their policies, was influenced by the conviction that it was necessary and much-required solution to the problems they discovered in their own in-house research. As noted by others, there was no better solution available to tackle the water pollution problem at the time (Scottish Water). Their confidence that SUDS would work was based on their first-hand experience of BMP's sites abroad, which they visited, and discussion with external experts. In contract, the employees of SEPA, scattered around Scotland, who were told the very same messages, but were not involved in their original discovery and exploration, were distrustful and resistant to adopt it. This was despite the communication methods between the management and the employees using, the then very innovative video and leaflets, on top of the internal, formal communication. Records from the SUDS WP meeting suggest that misinterpretation and ignoring the new policy by SEPA officers, especially in the early stages of SUDS introduction was common. Further engagement of SEPA management, via talks, workshops and consultations, at various SEPA branches across Scotland, gradually embedded the compliance to policy. Yet, the SUDS WP meetings records refer to compliance changing to non-compliance following changes in management of local SEPA braches. In summary, discovering a problem and identifying

solution was sufficient to trigger the action of those involved in the process, suggesting that the trust in their own conclusions and the vested interest created alongside, were essential. By reverting the same logic, those who were given the results, even via innovative communication channels, were reluctant and needed to develop the trust, interest and compliance over time, with evidence of this process still taking place in some locations.

### 7.4.6. ***Repeated use of SUDS***

The process of legislating SUDS, embedding it in regulations and technology provides a framework, which adds credence to the belief that the process was underway and SUDS will routinely used across the industry. The expertise build across the many individuals including in academics, policy makers and professionals, during the process of SUDS development and implementation has created a large cohort of SUDS experts, who based their careers on further development of SUDS. For example, students who monitored SUDS features continued their careers in the water industry, further promoting SUDS:

- A female researcher who worked for a big environmental consultancy upon completion of her course, she then moved to the Environmental Agency, and then back to private sector consultancy. Her work on SUDS throughout that time can be traced through her publications.
- A student researcher became a SUDS coordinator at SEPA and played a significant role in the promotion of SUDS through contribution to the SUDS Working Party, and the development of SUDS or Roads' guidance.
- A student whose work was based on DEX monitoring stayed in academia researching and teaching SUDS at a Scottish university.
- An example from beyond DEX, but related to the involvement of students in SUDS research, referred to Knowledge Exchange Partnerships (KEP) at Coventry University. A researcher from Coventry University worked as a KTP associate in the company producing the permeable pavement, Formpave, developing SUDS technology. On completion of the programme, he was offered an industrial PhD studentship to continue work on his SUDS research. Upon completion of the PhD, he was offered the position of the Director of Research at the same company, while he also remained employed by the university. His double association allowed him to champion many collaborative research projects, and sponsor further PhDs and student placements with the outlook for development and commercialisation of the SUDS technology.

- Examples can be found amongst professionals who trained during DEX constructions and remained in the industry:
- A former SEPA champion continued promoting SUDS throughout his career, he completed a PhD on the topic and created an environmental consultancy focussed on SUDS solutions
- In 2011, two environmental consultancies located in Edinburgh were bidding for local SUDS developments. Both were championed by individuals previously working jointly on DEX and whose expertise of SUDS was initiated at the Dunfermline Expansion Area development.

### 7.5. Method on Change of Practice and Impact of Change of Practice (IChoP)

Milestones, later referred to as instances, were selected according to the criteria of *Change of Practice*. Each instance of *Change of Practice* has been analysed by identifying the trigger(s) that caused it, and its consequences, which would fall under the category of *Impacts of Change of Practice*. They were further analysed to determine whether there is a link between the triggers and consequences of separate instances of *Change of Practice*. Data are presented six instances of *Change* of *Practice*, representing the initial stages of SUDS introduction. Examples of both triggers and impacts are based on records from interviews, the SUDS WP records and online materials. The list of triggers and impacts is not exhaustive. In the analysis of milestones it is also mentioned if there is evidence for the *engagement benefits*.

### 7.6. Data on Change of Practice and Impact of Change of Practice (IChoP)

Table 17 SUDS milestones

| Milestone 1 |
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| Inclusion of SUDS into new SEPA Policy 15<br>**Trigger**: new evidence on water pollution emerging from in-house research and need to address water pollution 14<br>**Impact**: stakeholders in the construction and water industry were affected as they could no longer receive consents for drainage unless they adhered to the new policy. As a result, all developments stopped. A stakeholders group: the SUDS Working Party was set-up. |
| **KE features**: Reference to **trust** between the authors of the original FRPB report on water pollution and the FRPB leadership, later SEPA, mentioned as an essential feature of the process leading to the introduction and sustaining of the policy despite the |

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| turmoil in the industry caused by it. **Trustful relationship** also referred to the team of SEPA's officers involved in the initial enforcement and implementation of the policy. **Trust** referred to as being essential during any period of uncertainty and risk taking. Reference made to the importance of **flexibility regarding interpretation of what SUDS is** and **how it is implemented** in the process of getting a buy-in and encouraging implementation of SUDS by developers. |
| Milestone 2 |
| Set-up of the SUDS Working Party<br>**Trigger**: the need to address the construction stoppage, caused by uncertainty introduced by SEPA's new Policy 15<br>**Impact**: representatives of major stakeholders from water, environment, and construction sectors start collaborating on the development of SUDS guidelines, raising the awareness and profile of SUDS, aligning policy developments and mutual relationships where SUDS ownership is not clearly defined, coordinated promotion and development of SUDS in Scotland, commissioned research on SUDS, established a long-term body representing and lobbying for SUDS in Scotland |
| **KE features**: reference made to **trust** needing to be reinstated within the industry; reference made to standardising **language and jargon** related to SUDS; reference made to a **collaborative approach** to all stages of SUDS development and implementation; reference made to **trust building** between individual members of the group that enabled the pushing of the SUDS agenda, reference made to **lack of trust** preventing developments. |
| Milestone 3 |
| Development of the first CIRIA SUDS manual<br>**Trigger**: lack of technical standards, lack of legislation and general lack of knowledge about SUDS, specific to Scotland within the industry.<br>**Impact**: created the first industry-endorsed guidelines for SUDS; provided a focus for collaborative work, triggered process of research and generation of evidence for SUDS construction and performance; raised awareness; due to external changes in the law, this manual has not achieved the purpose of regulating stakeholders' mutual responsibilities towards SUDS. |
| **KE Features**: reference made to collaborative effort and learning by doing in the process of creation of the manual; reference made to SUDS being a **flexible concept** |

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| that has different implications to each stakeholder involved in the construction process, and requiring adaptation with every local application. |
| Milestone 4 |
| First implementation of SUDS features in a large-scale development (DEX)<br>Trigger<br>– Planned development could not go ahead unless including flood prevention measures, which SUDS offered;<br>– Local watercourses were polluted.<br>Related factors, which were not the triggers for DEX, but supported SUDS implementation in DEX<br>– Access to practical expertise and experience from abroad.<br>– Malmo Conference attended by key stakeholders involved in DEX construction resulted in SUDS being embraced and promoted with confidence and collaboratively<br>**Impact** – possibility to develop a site on a flood plain, otherwise unsuitable for development; first large SUDS exemplar site built, which became a widely cited reference to SUDS; creation of a practical skillset amongst practitioners and researchers gained in the process of constructing, installing and monitoring features of SUDS; creation of a cohort of SUDS specialists across industry and academia who later linked their careers to SUDS; raised profile for SUDS in Scotland and beyond. |
| **KE Features:** Reference made to **trust** building between stakeholders involved in the construction DEX as essential for generating momentum and permitting risk-taking. Reference made to the trust building process involving sufficient time spent together and mutual respect. Reference made to **learning by doing** by all involved, in some areas **facilitated** by an experienced external expert. Reference made to **expertise growing** within the stakeholders group and evidence suggesting that many involved in DEX remained in the area of **SUDS as experts** and developed and reused the knowledge gained during DEX construction. |
| Milestone 5 |
| Defining SUDS as a "sewer" and bringing it under the legal remit of Scottish Water<br>**Trigger**: Opportunity created by the devolution of Scotland and associated legislative changes, including the EU issued Water Framework Directive, with further consequences resulting in the creation of Scottish Water and a requirement to redefine the scope of the new water authority. Ongoing work and lobbying by the SUDS WP |

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| members aimed as legislators to include SUDS into the new law by defining it as "sewer".<br>**Impact**: Scottish Water becomes legally responsible for SUDS. Scottish Water commissions research to inform the development of its new technical guidelines 'Sewers for Scotland 2nd Edition'; Efforts undertaken by the SUDS WP while developing the CIRIA Manual to define relationships between stakeholders in SUDS become obsolete as the remit is now (re)defined by law; negotiations between Scottish Water and Local Authorities Roads departments start, as SUDS falls between the jurisdictions of both; 'Section 7 Agreement' that used to regulate this relationship requires renegotiation as they are now separate organisations; implementation of SUDS in construction terms delayed for 7 years (until the publication of 'Sewers for Scotland 2'), due to lack of technical guidelines from Scottish Water, who is reluctant to vest SUDS as its financial implications determined by technical standards are uncertain. |
| KE features:<br>Reference made to **lack of flexibility** on the side of Scottish Water with regards to implementation of SUDS slowing down implementation of SUDS in Scotland; reference made to learning in the process of research and implementation; |
| Milestone 6 |
| Including SUDS into Sewers for Scotland 2<br>**Trigger**: SUDS falling under the remit of Scottish Water following WEWS.<br>**Impact**: All SUDS features adhering to the technical standards are vested by Scottish Water |

### 7.7. Discussion: Change of Practice and Impact of Change of Practice (IChoP)

SUDS implementation process and techniques used provide an illustration to all types of impacts on *Understanding*, *Change of Practice* and *Impact of Change of Practice*. The challenge to interpretation of historical data results from the often general statements used by the interviewees regarding the process overall; the possibility of them forgetting or selecting events; and attributing outcomes to specific interventions and ignoring other events. Records from the SUDS WP provide a source against which interview records were checked, as they were created contemporarily to the events.

#### 7.7.1. *Impacts falling under the category of "Understanding"*

- *Increased knowledge, skills and understanding* amongst practitioners, students, regulators and authorities as reported in interviews citing collective learning

during DEX and by published research and reports.

- *Changed attitudes and increased confidence* of DEX reported as a result of the key DEX stakeholders attending the Malmo conference; growing buy-in of all relevant professions in Scotland including those most resistant, the Roads Authorities.
- *Provision of new information* as a result of the publications of multiple SUDS technical guidelines
- *Identification of further needs* as a result of the monitoring of SUDS implementation locally by members of the SUDS WP, academic research
- Creation of innovation – the SUDS triangle,

### 7.7.2. ***Impacts falling under the category of "Change of practice" include:***

- *Individual behavioural change*: multiple examples across stakeholders in SUDS: e.g. SEPA's employees introduce new policy, DEX developer endorses SUDS
- *Use of new technology*: multiple examples across all SUDS domains less elaborated on in this thesis, e.g. application of permeable pavements, and road surfaces, over ground water storage solutions in and beyond DEX
- *New evidence integrated into policy*: including SUDS into SEPA's Policy 15, WEWS, Building regulations, CAR, etc.
- *Creation of new institutions, projects or groups*: establishment of the SUDS WP, multiple research projects (SKiNT), and companies developing SUDS technologies.
- Use of knowledge, technology or tools: e.g. DEX exemplar site.
- *Change in organisational process or decision making*: e.g. Scottish Water after introduction of WEWS and Sewers for Scotland.

### 7.7.3. ***Impact of Change of Practice***

The impact of installed SUDS features on local sustainability by using the measures of water quality, quantity and amenity has been researchers in multiple studies and research projects (Roesner et al., 2001; Heal at al., 2006; Bastien et al., 2010). In that, a link can be made between cumulative effect achieved by many instances of *Change of Practice* across the sector characterising the introduction of SUDS to Scotland and improved sustainability of certain geographical locations with regards to surface water management. However, looking at individual instances of *Change of Practice* within that big picture, and their impacts, a slightly different picture emerges. One *Change of practice* influences another one or more *Changes of practice,* which have further direct

or indirect consequences for following *Changes of practice*. For example, introduction of the new SEPA policy (Milestone 1, Table 17) did not have an immediate impact on improvement of urban sustainability, but triggered a series of further *Changes of practice:*

- Initial negative impact on the construction industry in Scotland resulting from disturbing the status-quo and introducing uncertainty, which led to stoppage of all construction projects (impact of Milestone 1, Table 17).
- Subsequently, stakeholders in the water sector in Scotland come together to address the turmoil and create the SUDS Working Party (Milestone 2 and impact of Milestone, Table 16), who developed the first SUDS (CIRIA) Manual (Milestone 3 and impact of Milestone 2, Table 17).
- Subsequently, the development of the SUDS exemplar site: the Dunfermline Expansion Site (Milestone 4, Table 17), permitted on the condition of using SUDS. The DEX provided stakeholders with an opportunity to learn how to build SUDS, and later to monitor its performance.
- Started the public debate on SUDS which was sufficiently mature when the opportunity arose to legislate SUDS, by defined it as 'sewer' in the Scottish Water technical guidelines: 'Sewers for Scotland 2' (to Milestone 6, Table 17).

The case study also illustrates how introduction of an external higher-level policy interrupted and redirected the process started by the aforementioned introduction of SEPA policy. The higher-level policy was the Water Environment and Water Services (Scotland) Act (WEWS) introduced by the Scottish Parliament in order to transpose the European Water Framework Directive (WFD) into Scottish law, and had the following consequences (*Changes of practice*).

- The WEWS Act amended the Sewerage Act and extended the drainage definition to include SUDS, and thus gave SUDS a legal 'owner'.
- 'Sewers for Scotland 2' was created as a result of WEWS to ensure that SUDS would be vested by Scottish Water (SW) following WEWS are constructed according to SW standards.
- 'Section 7 Agreement' of the Sewerage Act determines how responsibilities between Scottish Water and Local Authorities are shared once they are agreed. It was agreed at the end of the process of creation of 'Sewers of Scotland 2'.
- Controlled Activities Regulations were passed in 2005 as a WEWS implementation milestone. They were updated in 2015.

In addition, WEWS has only been possible, since other industry geo-political changes were taking place, which all contributed to the process of SUDS implementation, not directly related to SUDS.

- The creation of the Scottish Environmental Protection Agency (SEPA) in 1996 as one regulatory organisation, combined the River Purification Boards from across Scotland. This provided an opportunity to spread the Forth River Purification Board's innovative approach to diffused pollution across the country.
- Scottish Devolution in 1998 created the opportunity for legislation to be made in Scotland. It enabled water and environmental laws related to SUDS to be passed independently from other parts of the UK. It also enabled Scotland to respond to the UE directives independently from the rest of the UK.
- The creation of the Scottish Water out of the three pre-existing water authorities in Scotland that coincided with a new legislation (Water Environmental and Water Services At) in 2003 and provided an opportunity to include SUDS into drainage duties of the newly established organization.

Considering the above examples makes it evident that it is difficult to see the impact of *Change of practice* unless sufficient time has passed. By the same logic, interpretation of impact of practice change is prone to mistakes and over-interpretation.

### 7.8. Impacts on Understanding and that on Change of practice

The impacts on the area of *Understanding* could be attributed to multiple interventions and external factors, like the dissemination techniques described in 7.3.1. and triggers such as compliance with the policy of their own organisation, higher-level policy or the need to align with changed introduced by other stakeholders in the interconnected construction industry, on top of their own motivation and environmental consciousness. Only one instance provides enough evidence to attribute the impact on *Understanding* to a specific research (employees and management of the Forth River Purification Board influenced by the results of their own in-house research).

- The evidence suggests that impacts on the area of *Understanding* could have triggered impacts on *Change of practice*. This can be deducted from the reverse logic, that a lack of impacts on the area of *Understanding* prevented *Change of practice*. Analysis of the factors negatively influencing implementation of SUDS in various geographical areas and amongst some stakeholders included:
- **Lack of know-what and know-how:** misinterpretation of SUDS guidelines by SEPA employees and inconsistencies in advice given (E.1, E.15) lack of clarity

regarding responsibilities / shared ownership (E.3, E.17, E.23)

- **Lack of Motivation/ buy-in / compliance / trust:** lack of compliance of developers with agreements (E.15, E.17) unwillingness to adopt, mistrust regarding new solutions (E.6, E.9, E.11, E.14, E.16); inconsistencies within and across local authorities interpretation of SUDS requirements (E.4)
- **Lack of evidence:** insufficient or inconsistent evidence on SUDS performance and safety (E.7, E.8, E.10, E.13, E.20, E.22) lack of information (E.9, E.12)

Evidence also shows how collaborative approaches were used to influence attitudes of stakeholders in the industry (falling under the category of *Understanding).*

- Ensuring attendance of those blocking SUDS at an international conference in Malmo was one of the strategies.
- Inviting 'opponents' to jointly author publications where the stance of both sides was examined and a dialogue was started. SUDS champions believed that by engaging with opinion leaders representing opposing views on SUDS sent a message to industry that SUDS is being considered by them too.
- Inviting 'opponents' to chair conferences where SUDS was discussed to expose them to the evidence and research and thereby creating opportunities to discuss the differences.

### 7.8.1. *Change of practice vs impact of change of practice*

The gradual alignment of inter-dependent stakeholders in the built environment, introducing *Changes of practice* as a reaction to changes introduced by one of them corresponds with the process of change in a socio-technical system proposed by sustainability transitions. The *Changes of practice* preceded and followed by changes to *Understanding* are all part of sustainability transition and can be assumed to ultimately lead to improvement of sustainability in urban environment. It is also in line with the theory of path dependency, where legislative changes once started, are unlikely to change its direction when faced with alternative evidence to avoid costs (time and other investment). The path dependency does not apply when higher-level legislation imposes new direction.

In light of the multi layered and gradual changes, it can be concluded that individual *Changes of practice* are unlikely to make a direct impact on sustainability of the urban environment, but they rather trigger further *Changes of practice* until the whole sector is aligned. Instances when individual *Change of practice* (introduction of SUDS feature)

on a level of construction projects can have direct impact on urban sustainability in this particular location, but those changes may not be permanent. An example of *Change of practice* within a construction project compliant with laws of one organisation (e.g. SEPA) but not compliant with laws of another (Scottish Water) shows that despite the sustainability of that particular development being improved, it may be compromised in the future. This is because the long-term maintenance of SUDS features does not fall under anyone's responsibilities, hence it might be neglected and not perform appropriately.

# CHAPTER 8 CASE STUDIES: SUSTAIANLE URBAN ENVIRONMENT PROGRAMME (SUE)

## 8.1. Case 1: AUNT SUE and AMELIA

The AUNT SUE "Accessibility and User Needs in Transport for Sustainable Urban Environments" consortium run between 2004 and 2010 and was led by London Metropolitan University, Loughborough University and University College London.

The project partners included the London Borough of Camden, Hertfordshire County Council and a network of local, regional and transport authorities.

The consortium aimed to develop a comprehensive 'toolkit' integrating policy, design and operations throughout the whole journey environment. It could be used at different scales, from city-regions down to the micro-level of streets, vehicles and facilities such as bus stops, signage and ticket machines. They created tools such as: HADRIAN: Human Anthropometric Data Requirements Investigation and Analysis (a Computer Aided Design-based tool), I-Journey: Inclusive Journey Planner (web interface), Journey Stresstimator (a Microsoft Excel add-on) and the GIS-based Street Design Indicator, Street Environment Index, and AMELIA (A Methodology For Enhancing Life by Increasing Accessibility). The development of the last one is analysed in the section below.

### 8.1.1. *AMELIA*

A Methodology For Enhancing Life by Increasing Accessibility, is a tool that aims to "present the user with a set of possible policy actions relevant to the policy objective being considered, and then to quantify and map the effects of these policy actions to help the user to assess which is the most effective" (Mackett et al., 2008)

The AUNT SUE team working on AMELIA involved a principal investigator (further referred to as R1), a group of researchers (further referred to as RS) and a number of Local Authority staff (referred to hereafter as P1, P2).

The collaboration resulted from the existing personal contacts between R1 and P1 made during a previous EPSRC funded project. P1 agreed that the local authority would provide access to local data and help researchers to make the tool relevant to their policies. Researchers jointly with practitioners explored how accessibility could be improved in the areas of the most concern to the local authority. They consulted the local communities

in question and in so doing they ensured that the criteria used to build the tool supporting decision-making based on the real needs of groups at risk of social exclusion. Researchers have also delivered presentations and group discussions at the local authority. These were not as successful as expected. *"Researchers seemed to stick to academic formats for presenting the results of the project, which was sometimes difficult for the LA stakeholders to be involved in. LA people do not read academic papers. They should try more general transport publications. If you want to get LA involved talk to them in a way they understand rather than in an academic language"* (Practitioner-P1).

The local authority staff contributed to the collection of physical of data that was not readily available by physically measuring kerbs and pavements. They recalled that researchers sometimes expected too much from the local authority with regard to data and contribution.

"The local authority staff found it very labour intensive. It took three members of staff a day to do one street! The data was then fed back to AMELIA researchers who then put it into AMELIA for them. Some maps were produced but the project stopped here. The LA would have liked to have done more with the project but it was too resource intensive" (Practitioner-P2).

The aim of the research was to embed the new knowledge into a software tool that was based on Geographical Information System (GIS) interface. At the testing stage, it was discovered that the GIS interface used by the local authority was not compatible with that used by researchers.

Due to various circumstances and despite encouragement and willingness to participate, the actual involvement of local authority employees was limited to providing access to data. Researchers' and practitioners' work did not overlap beyond data exchanges and, as a result, practical knowledge generated in the process of tool development, and analysis was gained by the researchers only. The testing of the tool that might have provided another opportunity to gain hands-on experience of the tool, was also performed by researchers only. This was partly due to time constraints of the local authority staff, but was mainly due to the incompatibility of the software systems.

Reflecting on their experience, the local authority participants referred to the difficulties in timescales, languages, and frames of reference when communicating with researchers.

They felt they benefitted through learning the different ways of thinking about their work, but did not have the skills or resources required to use the tool for other analysis beyond the project duration.

The specific policy options that researchers generated using AMELIA were transposed into local transport policies in two separate cases. In the case of the implementation of those policies, the research findings might have an impact on urban sustainability of the specific location of the council. The research also proved that the tool can support decision making in transport policies. However, the tool was not used in that local authority beyond what was done during the research project, and there was no outlook for further funding to develop the tool at the time of the interview, in 2011. An online search performed in 2016 to investigate whether the tool has been mentioned in any further online records past 2011, brought no additional results.

Collaboration with a university was reported to have raised the profile of the local council. Despite difficulties, both sides said they learned from the process, were happy with the relationship, and were interested in future collaborative work. The interviews were not contacted again after 2011, when the data collection for this research has finished, so no further evidence is available as to the further collaboration between the parties.

### 8.2. Case 2: IDCOP

The "Innovation in Design, Construction & Operation of Buildings for People" (IDCOP) project ran from July 2004 to February 2009. The project involved the Universities of Southampton, Reading and Greenwich. The research investigated how it was possible to achieve a more sustainable urban environment, focusing on the UK building stock and developing new technologies and processes for maintenance and refurbishment of existing buildings.

Two researchers (hereafter referred to as R1 and R2) from the IDCOP consortium engaged with the head of a Sustainability group in a multidisciplinary engineering consultancy for the built environment (referred to as P1). The consultancy that employs 250 staff working in London, Farnborough, Manchester, Paris, Milan and Abu Dhabi, was not formally a partner on the project.

Engagement was initiated when R1 informally asked P1 for feedback on the final report of the IDCOP project. The informal nature of the request was possible due to an existing relationship between R1 and P1 that went back over several years, with P1 contributing to the R1's Master's programme, as a guest practitioner lecturer. The report triggered a

series of discussions and involved R2, whose methodology for master-planning the assessment framework described in the report, prompted P1's interest. The discussions led to 5 year-long collaboration, which, in turn, led to the development of a software tool SuBET (Figure 7)

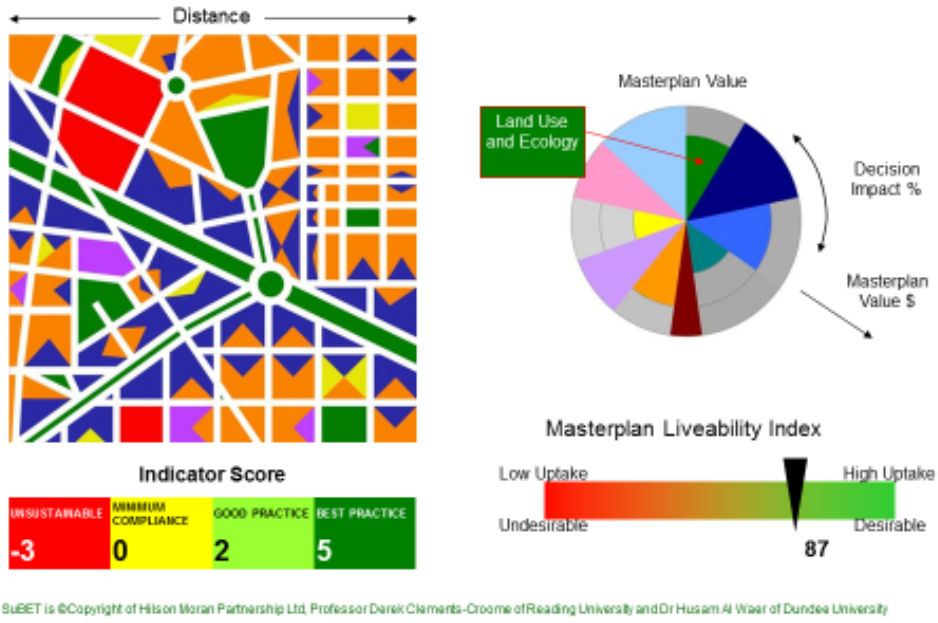


Figure 7 SuBET tool (IDCOP presentation, 2011)

The original assessment framework, described in the R2's PhD thesis, with which the work commenced, was adapted and changed into a new set of conditions, while utilising the underlying principles of their original work. The collaboration involved meetings, talks and discussions with other employees of the consultancy regarding methodology, sustainability criteria and sustainability theories. In 2009, the company announced launching the tool and a new Steering Group for Sustainable Master-planning, involving R1, R2, and P1. The company announced that their use of the tool would be verified by the academics – ensuring a high quality of assessment.

When asked about their experiences, both researchers and consultancy employees referred to communication challenges and a long process of consensus building rewarded by the understanding of each other's perspective. R1 and R2, apart from benefits related to working with the company, continued to involve P1 into their teaching Programmes. At the time of data collection, the SuBET tool was in its 3rd version and was being tested on two real-world oversees projects the company was involved in. Researchers witnessed how their original research was understood by practitioners, how they developed it and

embedded it in a software tool. They contributed to this process and oversaw the tool being utilised in real-world master-planning projects.

In 2014, information published online claimed that the tool has been patented, tested on a wide range of real world projects and contributed to the company winning a sustainability award. It further suggested that SuBET became the company's flagship sustainability assessment tool, which is still being utilised. Hence it may be assumed that it is likely to have a lasting impact on sustainability of the built environment around the world.

### 8.3. Case 3: SUSTAINABLE EASTSIDE

The Sustainable Eastside project took place between May 2003 and June 2008 and was run by the Universities of Birmingham and Birmingham City. The aim of the project was to explore how sustainability is addressed in practice in the regeneration decision-making process and to assess the sustainability performance of completed development schemes against stated sustainability aspirations.

The timing of the research coincided with the beginning of the Birmingham Eastside, a large, city-centre, regeneration scheme. Birmingham universities formed part of the Eastside Sustainability Advisory Group (ESAG), which oversaw the implementation of the "Sustainable Eastside - A Vision for the Future". ESAG scrutinised the proposals; encouraged the implementation of sustainable development; consulted with key stakeholders; and signposted environmental techniques and standards which contributed and oversaw the creation of the vision for the area regeneration. This engagement enabled the SUE project created alongside to benefit from the established connections. The Sustainable Eastside researchers were looking to identify and approach local stakeholders involved in the regeneration process. One of the organisations expressed an interest in working with an academic partner. The engagement comprised of prolonged interactions where researchers observed practitioners' project team meetings, fed back observations and findings, and provided evidence for sustainability related aspects of the development (i.e. on utility infrastructure, land use mapping, and biodiversity issues) and sustainability focused training for the practitioners' team. In return, they were granted access to staff for interviews, to project team meetings and plans, and were introduced to other practitioners in the field. The nature of the engagement provided enough time and motivation for both sides to overcome communication barriers related to jargon, different knowledge references, and timescales. It enabled them to learn from each other and implement that learning in further actions with the shared collaboration driver being to

find solutions for specific problems, local to their geographical area. Their 3 year-long collaboration changed from: "*observer/observed to one of shared experience and expertise, and an evolving mutual understanding of each other's strengths and weaknesses*" (Lombardi et al. 2008). The multiple benefits from the collaboration, identified by both parties involved and listed in Table 18, can broadly be summarised as betterment and enrichment of both researchers and practitioners in what they were doing in their jobs, and a commitment to continue this collaboration.

Table 18 Collaboration benefits to researchers and practitioners (Lombardi et al. 2008)

| Benefit | Practitioners | University researchers |
|---|---|---|
| Access to funding | Public sector demanding sustainability credentials – work with researchers validates their efforts in this arena. | Research councils requiring dissemination to, involvement with, demonstrable impact on, non-academics – work with the company satisfies these criteria. |
| Credibility with stakeholders | Public sector demanding evidence of sustainability credentials. | Engagement with stakeholders is indicative that research is yielding useful knowledge, not just theory; involvement with developers brings attention from more developers. |
| Validation | Researcher evidence base tapped to advance thinking and validate or challenge best practice. | Grounds observations in real world to improve applicability of work and validate relevance. |
| Source of new ideas | Researchers help to develop practitioner thinking through a rigorous, structured, academic approach. | Practitioners help to generate new research questions through shared experiences and challenges. |
| Access to expertise/ information | Research experts provide latest thinking to the company to advance sustainability agenda. | The company provides expertise on mainstream practice, leading edge practice, and offers insights into the drivers of behaviour. |

| | |
|---|---|
| Access to networks | Both parties have introduced the other to expert resources, relevant conferences and meetings, at times facilitating attendance through introductions. |
| Navigating the landscape | Both parties have sought advice on the expectations of attendance at certain events, and the possible value to be derived from that investment. |

Table 19 Collaboration challenges to researchers and practitioners (Lombardi 2008)

| Challenge | Practitioners | University researchers |
|---|---|---|
| Timing | Time constraints often mean practitioners need to act quickly, without the luxury of time to fully explore all options. | Researchers often plan for certain research to last for months or years, expecting to publish only a few academic papers because of the lengthy research project. |
| Rigour | Practitioners often act on the 80/20 rule: making a decision on 80% of the information available in 20% of the time it would take to get the full answer. | Researchers are accustomed to pursuing 100% of the answer through rigorous research which may take substantially longer and lead to as many questions as answers |

Tables 18 and 19, outlining the benefits and challenges of collaboration has been extracted from a paper authored jointly by researchers and practitioners, which confirms their mutual understanding of each other's issues and drivers for working together.

### 8.4. Case 4: ISSUES project

The Implementation Strategies for Sustainable Urban Environment Systems (ISSUES) project was run collaboratively by Heriot Watt and Cambridge Universities between 2007 and 2011. It was set up by the EPSRC with the remit of supporting and enhancing knowledge transfer from the "Towards Sustainable Urban Environment" (SUE) programme. It overlapped with the final stages of the SUE1 consortia, and initial phase of the SUE2. The SUE3 projects fell outwith the lifespan of ISSUES.

The strategy of the ISSUES was to engage (Figure 7) with three groups of stakeholders: researchers, research funders and built environment practitioners. Its main aims were:

- to support knowledge sharing within and between them,
- to identify research findings and end-users they could be relevant to,
- to stimulate the uptake of SUE generated knowledge.

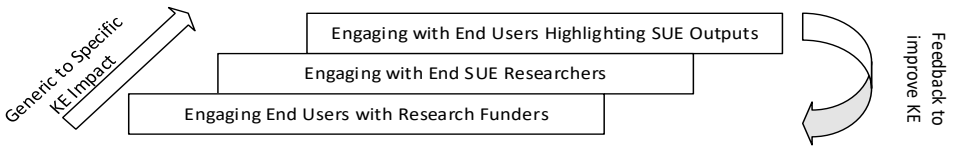


Figure 8 ISSUES engagement strategy

The ISSUES project was separate from the SUE consortia, yet it represented the SUE research to a wide range of potential end-users. This posed several challenges to the ISSUES:

- The spatial spread and multidisciplinary breadth of SUE resulted in limited personal contact of the ISSUES and SUE staff members.
- The diversity and number of all stakeholders, both researchers and end-users was very high. The project included engineers, architects, planners, and builders from both the private and public sectors and research staff at all career stages from 18 different institutions.
- A degree of "protectionism" by some of the SUE consortia required long term trust building process by the ISSUES team.

The approach that the ISSUES team adopted fell within the scope of knowledge brokering. The analysis of the ISSUES activities in the context of knowledge brokering resulted in a published conference paper (see Appendix G).

### 8.4.1. *Knowledge brokering*

Knowledge brokering refers to the "processes used by intermediaries (knowledge brokers) in mediating between sources of knowledge and users of knowledge" (Bielak et al. 2008). The general purpose of knowledge brokering is to improve knowledge exchange for the wider benefit of all (Bielak et al. 2008). Knowledge brokers can be individuals, projects, organisations or bigger organisational structures. They are the 'intermediaries, who link the producers and users of knowledge to strengthen the generation, dissemination and eventual use of knowledge' (Bielak et al. 2008).

Table 20 List of engagement mechanisms used by the ISSUES project

- Information portal/search engine (SUE Gateway)
- Web directory of expertise (SUE Gallery of Experts)
- Online video portal (SUE Explains Vidiowiki)
- Events (Ebbsfleet Challenge, Brave New City, etc.)
- Tour of research inspired movie poster
- ISSUES publications and reports translating SUE research
- Feature articles about SUE in trade media
- Summarising research portfolios into plain language
- Newsletters, postcards, events
- SUE Exchange meetings for researchers
- KTN network 'connect' platform
- Advocacy meetings
- KT Guidebook for Researchers
- Impact training for Researchers

In its role of managing the knowledge generated by SUE, the ISSUES project researched, categorised, translated and redistributed knowledge**.** The project translation of knowledge was required to enable end-users to understand publications written using the academic jargon of different disciplines. The ISSUES team summarised research portfolios into plain language, distilled messages from complex reports, and formatted information to suit new media and online tools.

The ISSUES research suggested that practitioners preferred to access new knowledge via the internet and ideally through one portal (Cloughley and Beckmann 2010). As a response, ISSUES created a collective online representation of the SUE programme, using modern communication techniques, such as:

- The 'SUE Gateway' portal, allowing practitioners to search for evidence and tools in the SUE Programme from one single online space (Figure 9)

- The ‘SUE Gallery of Experts’ providing summaries of and access to the expertise created by the SUE Programme in all areas of urban sustainability (Figure 9)
- The SUE EXPLAINS Vidiowiki - an interactive forum with linked videos, where researchers, policy makers, and practitioners linked to SUE explain their work in a three-minute synopsis, featuring summaries of SUE research presented by SUE researchers themselves.

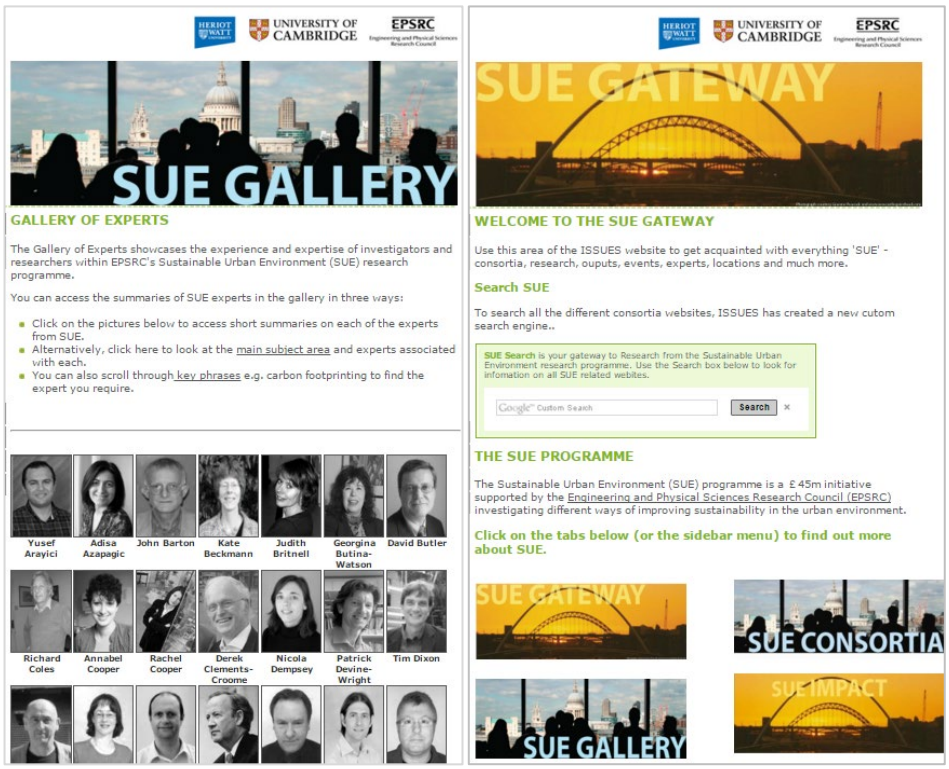

Figure 9 SUE Gallery and SUE Gateway

ISSUES combined online dissemination with traditional printed marketing materials. It used them for collective and tailored broadcasting. A journalist working on the ISSUES project prepared 311 articles about SUE research findings, which were sent to 22 professional magazines and publications relevant to urban environment practitioners (Cloughley and Beckmann 2010).

The ISSUES project organised events that aimed to bring together researchers and practitioners, both in the capacities of speakers and audiences. The first event, organised in the vicinity of a new development Ebbsfleet, attracted practitioners who were associated with the development, we well as academics from across SUE, with no direct

link to it. It highlighted that this format of short engagement opportunities can reinforce stereotypes of academics' use of jargon and too lengthy speech formats addressing practitioners who quickly become uninterested. The ISSUES team members, recalled that academic speakers at the event, although aware of the audience composition of policy makers and practitioners, rarely succeeded in adhering to the communication guidelines used by the ISSUES project own dissemination practices.

Subsequent events of the ISSUES Project sought to use more engaging and innovative formats. The 'Brave New City' event series, held in Edinburgh and London was an example of this. The invited panellists were asked to introduce a clip chosen from the ITN Source broadcast footage provider to spark off their discussion of the Brave New City. The stature of the speakers attracted interest in the event from the outset. The event attracted two media partners: *The Architects' Journal* and *IKT magazine.* In addition, 75% of the audience were practitioners from both the private and public sectors.

In addition to events, ISSUES team used direct one-to-one engagement methods through advocacy meetings with government representatives (e.g. Department for Environment, Food and Rural Affairs, Department for Transport, Department of Communities and Local Government). The meetings were aimed to promote SUE as a source of evidence for policy making, to direct people to SUE knowledge repositories collected and available on the website, and to encourage further contact with SUE researchers. Fourteen institutions were approached, which resulted in contact being made between SUE researchers and policy makers (ISSUES Final Report 2013).

ISSUES used the virtual platform, the Knowledge Transfer Networks *"connect*" platform and physical spaces to link SUE researchers with the end-user groups. Metrics of virtual networking were not available at the time of this analysis, as the connect platform had only just been created. Physical events for researchers and end-users were effective in attracting audiences, but evidence for their effectiveness in creating further connections was not monitored.

The ISSUES project created and delivered workshops for researchers to address obstacles to the effective communication with practitioners. The workshops introduced tools and knowledge exchange principles. They also hosted guest speakers from the end-user community to explain their knowledge seeking habits, as well as researchers' own

accounts of knowledge exchange. The workshop entitled “Knowledge Exchange Health Check” was delivered at multiple research development occasions after the completion of the ISSUES project. For example, for the last 4 years they formed part of an early career researcher development programme called “Crucible”, at Heriot Watt University.

# CHAPTER 9 DATA ANALYSIS: SUE

## 9.1. Introduction

This chapter consists of sections on data, analysis, results and discussion. Sections 9.2-9.5.2 concern *engagement benefits* and sections 9.6 to 9.8 discuss the impact assessment framework.

## 9.2. Method: Engagement benefits

The literature review identified *engagement benefits* associated with effective knowledge exchange and circumstances, which favour, enable or prove that they occurred. Those circumstances were considered proxy indicators for each of the *engagement features* and referred to as *conditions* or *engagement conditions* (Table 21*)*.

Table 21 Engagement benefits and conditions of engagement

| Engagement benefits | Conditions (proxy for the engagement feature) |
|---|---|
| Trustful relationship | Frequency of direct interactions<br>Equity of relationship<br>Future plans |
| Communication leading to mutual understanding | Jargon-free communication<br>Frame of reference |
| Movement of all types of knowledge (enabling learning) | Practitioners' engagement with knowledge on the scale: read, discuss, argue, teach, use.<br>Practitioners' contribution to research at the stages of: design, data collection, analysis, testing, dissemination. |
| Knowledge utilisation | Knowledge format flexible for adaptation (usable).<br>Facilitation or witnessing of knowledge use or adaptation.<br>Repeated knowledge use beyond the project. |

The selection criteria for *engagement conditions* corresponding with *engagement benefits* included a) affiliation between them as established from the literature, and b) ability to observe or otherwise determine their occurrence retrospectively. For example, the *engagement benefit*: *trustful relationship* was assigned three *conditions: frequency of direct interactions, equity of relationship* and *future plans*. *Frequency of direct interactions* was selected based on evidence that development of trust occurs over time, implying that more than two meeting are required. The threshold of three meetings within

the duration of a research project was set as minimum for this condition to be met in this assessment. Therefore, the condition of *frequency of direct interactions* was assessed based on an *opportunity* for both parties to meet more than three times, where planned collaborative work is considered to provide a reasonable opportunity for that to happen. It is also assessed based on whether it can be *evidenced* with project and interview records. A list of anticipated or exemplary *evidence* and *opportunities* for each condition are listed in Table 22.

Table 22 List of expected evidence or opportunities for conditions of engagement

| Condition | Evidence = 1 | Opportunity = 1 |
|---|---|---|
| Frequency of direct interactions | Record of more than three direct interactions | Collaborative work |
| Equity of relationship | Reference in interview or/and project records of the roles each side played | Collaborative work |
| Future plans | Arrangements made (intention not sufficient) | Collaborative work resulting in tangible outputs or benefits for both sides |
| Jargon-free communication | Reference in interview<br>Materials tailored to the audience | Interaction<br>Materials tailored to the audience |
| Frame of reference | Reference in interview | - Interaction<br>- Opportunity to experience each other's circumstances e.g. secondments |
| Practitioners' engagement with knowledge: read, discuss, argue, teach, use | Reference made to reading, discussing the knowledge equals "0" as it only engages explicit knowledge<br>Reference made to teaching or using the knowledge equals "1" as it demonstrates that tacit knowledge was used/ developed | Access to knowledge |
| Practitioners' contribution research stages: design, data | Reference made to functions preformed in the project, where | Collaborative work<br>Flexible project set up |

| | | |
|---|---|---|
| collection, analysis, testing, dissemination | design, analysis, testing equal "1" and data collection, dissemination equals "0" | |
| Knowledge flexible for adaptation | Reference made in interview, project records | Flexible knowledge format<br>Flexibility of both parties |
| Facilitation or witnessing of knowledge use | Reference made in interview, project records | Collaborative work |
| Repeated knowledge use beyond the project | Reference made in interview, project records, other sources | Ownership status, practitioner's abilities and skills |

Each *engagement condition* was assessed qualitatively with regard to two criteria and assigned a value of 1 or 0, based on presence or absence of *opportunity* for the condition to occur, and *evidence* that the condition occurred (Table 23).

Table 23 Scores assigned to engagement conditions

| score | description |
|---|---|
| **2** | opportunity and evidence for occurrence |
| **1** | opportunity for occurrence |
| **0** | equals no evidence or opportunity for occurrence; evidence was negative; data unavailable |

As a result, each condition could receive a value ranging from 0-2. *Opportunity* was defined as a presence of circumstances where a given feature could occur or be developed (Table 20). *Evidence* was defined as a reference in the interview records or other material generated by research. To calculate a score for the likelihood of each *engagement feature*, the arithmetic mean was calculated. Scores for *engagement conditions* falling under *engagement feature* were added and the sum was divided by the number of *conditions* assessed, resulting in an overall score for each *engagement feature* ranging from 0 to 2. The average scores were interpreted as shown in Table 24:

Table 24 Engagement scale based on average score

| Score | Interpretation |
|---|---|
| **2** | it is highly likely that the *engagement benefit* is present as there was an opportunity and evidence for all *conditions.* |
| **> 1 & < 2** | it is likely that the *engagement benefit* is present as there was an opportunity and/or evidence for some *conditions* to occur. |
| **> 0 & < 1** | it is possible but unlikely that the *engagement benefit* is present, as there was an opportunity but no evidence for some *conditions* to occur, alternatively the evidence was that the *conditions* have not been met. |
| **0** | unlikely that the *engagement benefit* is present as there were no opportunities for any of the engagement *conditions* to occur. |

### 9.3. Data: Engagement benefits

Data are presented below in a tabular format for each case study for AUNT SUE - Table 25, IDCOP - Table 26, Sustainable Eastside - Table 27, and ISSUE - Table 28.

Table 25 AUNT SUE: Evidence for engagement features and conditions

| **AUNT SUE** | |
|---|---|
| **ENGAGEMENT FEATURE:** | Trustful relationship |
| **CONDITION:** | Frequency of direct interactions |
| **EVIDENCE:** | Reference made to multiple meetings between the research team and stakeholders contributing to the data collection, and to events and communication between senior representatives from both research and the city council (Score 1) |
| **OPPORTUNITY:** | Collaborative work, long term project with stakeholders involved form the outset (Score 1) |
| **ENGAGEMENT FEATURE:** | Trustful relationship |
| **CONDITION:** | Equity of relationship |
| **EVIDENCE:** | Reference made to unequal roles assigned and unmet expectations (Score 0) |

| | |
|---|---|
| **OPPORTUNITY:** | Collaborative work (Score 1) |
| **ENGAGEMENT FEATURE:** | Trustful relationship |
| **CONDITION:** | Future plans |
| **EVIDENCE:** | Reference made to potential interest in a future collaboration, depending on further funding, no specific plans outlined (Score 0) |
| **OPPORTUNITY:** | Project resulting in a tailored-made software supporting decision making (Score 1) |
| **ENGAGEMENT FEATURE:** | Communication leading to mutual understanding |
| **CONDITION:** | Jargon-free communication (Score 0) |
| **EVIDENCE:** | Reference made by end-users to researchers' use of jargon at meetings preventing others from understanding |
| **OPPORTUNITY:** | Repeated interaction (Score 1) |
| **ENGAGEMENT FEATURE:** | Communication leading to mutual understanding |
| **CONDITION:** | Frame of reference |
| **EVIDENCE:** | Reference made by practitioners to researchers' lack of understanding of their way of working (Score 0) |
| **OPPORTUNITY:** | Repeated interaction (Score 1) |
| **ENGAGEMENT FEATURE:** | Movement of all types of knowledge |
| **CONDITION:** | End-user engagement with knowledge |
| **EVIDENCE:** | Reference made to opportunities for practitioners to listen and feedback on the research project at events, involvement of practitioners in data collection<br>No evidence for practitioners testing or using the tool on their own or teaching others (Score 0) |
| **OPPORTUNITY** | No access to software (Score 0) |
| **ENGAGEMENT FEATURE:** | Movement of all types of knowledge |
| **CONDITION:** | Contribution to research process |

| | |
|---|---|
| **EVIDENCE:** | Reference made to practitioners collecting data in the field by measuring urban features; reference made to involvement of stakeholders in the initial research scoping process<br>No reference made to practitioners' contribution to analysis or testing (Score 0) |
| **OPPORTUNITY:** | Collaborative work (Score 1) |
| **ENGAGEMENT FEATURE:** | Knowledge utilisation |
| **CONDITION:** | Knowledge flexible for adaptation |
| **EVIDENCE:** | Reference to local data being fed into the software to generate locally specific results and applicability of the software to repeat the procedure for other locations, however software tool being complex to use, requirement for labour intensive data collection or each subsequent analysis, and in the local practitioner's context software plug-in was incompatible with the software platform available rendering it unusable (Score 0) |
| **OPPORTUNITY:** | Potentially flexible software platform (Score 1) |
| **ENGAGEMENT FEATURE:** | Knowledge utilisation |
| **CONDITION:** | Facilitation or witnessing knowledge use |
| **EVIDENCE:** | The results generated by researchers using the software were quoted in a local planning policy paper (Score 1) |
| **OPPORTUNITY** | Communication after the project completion (Score 1) |
| **ENGAGEMENT FEATURE:** | Knowledge utilisation |
| **CONDITION:** | Repeated knowledge use beyond the project |
| **EVIDENCE:** | Reference made to incompatibility of software to local IT platform, lack of skills amongst practitioners and lack of funding for data collection quoted as reasons for not using the software, however reports already generated is available for practitioners (Score 0) |

| | |
|---|---|
| **OPPORTUNITY:** | No access to software, incompatibility of software platform, no skills to use the software. Results generated already available to reuse (Score 0) |

Table 26 IDCOP Evidence for engagement features and conditions

**IDCOP**

| | |
|---|---|
| **ENGAGEMENT FEATURE:** | Trustful relationship |
| **CONDITION:** | Frequency of direct interactions |
| EVIDENCE**:** | Both sides refer to frequent meetings and interactions. Research records contain references to frequent meetings and join events (Score 1) |
| **OPPORTUNITY:** | Collaborative work (Score 1) |
| **ENGAGEMENT FEATURE:** | Trustful relationship |
| **CONDITION:** | Equity of relationship |
| EVIDENCE**:** | Both parties refer to each other as essential to the project. Practitioner approached for feedback on the research report, their feedback was acknowledged and led to further interaction - implies both sides input valued (Score 1) |
| **OPPORTUNITY:** | Collaborative work, interaction on professional level (Score 1) |
| **ENGAGEMENT FEATURE:** | Trustful relationship |
| **CONDITION:** | Future plans |
| EVIDENCE**:** | Reference made to further development of the software tool. Both parties involved in Steering Group for Sustainable Master Planning, arrangement in place for practitioner's contribution to teaching (Score 1) |
| **OPPORTUNITY:** | Collaborative work resulting beneficial outcomes (Score 1) |
| **ENGAGEMENT FEATURE:** | Communication leading to mutual understanding |
| **CONDITION:** | Jargon-free communication |
| EVIDENCE**:** | Reference made to the use of jargon, efforts made to replace jargon with plain language and/or explaining jargon to make it accessible (Score 1) |
| **OPPORTUNITY:** | Repeated interaction and feedback (Score 1) |

| | |
|---|---|
| **ENGAGEMENT FEATURE:** | Communication leading to mutual understanding |
| **CONDITION:** | Frame of reference |
| **EVIDENCE:** | Reference made by both parties to learning each other's way of thinking and understanding, referred to as one of the most valuable and fruitful elements of collaboration (Score 1) |
| **OPPORTUNITY:** | Repeated interaction and feedback (Score 1) |
| **ENGAGEMENT FEATURE:** | Movement of all types of knowledge |
| **CONDITION:** | End-user engagement with knowledge |
| **EVIDENCE:** | Reference made to multiple discussions and debates between both parties on the knowledge subject, its underlying principled and implications; practical demonstrations of the way the company works; in-depth explanation by academic of the rationale and foundations for the research methodology further developed into software tool; leadership of the company staff in the process of embedding the knowledge into software (Score 1) |
| **OPPORTUNITY** | Flexible and open relationship, full access to knowledge (Score 1) |
| **ENGAGEMENT FEATURE:** | Movement of all types of knowledge |
| **CONDITION:** | Contribution to research process (design, data collection, analysis, testing, dissemination) |
| **EVIDENCE:** | Reference made to the collaborative approach to exploring the existing research results and selecting elements of its methodology to fit the purpose envisaged by practitioner. This process involved redesign, using data provided by the company and knowledge brought in by academics, collaborative analysis and company led process of software development, multiple testing and redevelopment, dissemination and commercialisation of the tool. (Score 1) |

| | |
|---|---|
| **OPPORTUNITY:** | Flexibility of researchers to follow the lead of practitioner with regards to interests in specific types of knowledge and ways of working (Score 1) |
| **ENGAGEMENT FEATURE:** | Knowledge utilisation |
| **CONDITION:** | Knowledge flexible for adaptation |
| EVIDENCE**:** | Reference made to the extensive changes and amendments introduced to the original methodology that triggered interest of practitioner. Reference to transforming the methodology into software to full customisation (Score 1) |
| **OPPORTUNITY:** | Practitioner feedback and suggestions were invited, welcome and followed regarding knowledge content and format (Score 1) |
| **ENGAGEMENT FEATURE:** | Knowledge utilisation |
| **CONDITION:** | Facilitation or witnessing knowledge use or adaptation |
| **EVIDENCE:** | Software tool usage on variety of sites has been recorded in reports and presentations, feedback of academics was included regarding results and their interpretation (Score 1) |
| **OPPORTUNITY** | Both parties continued collaborating as the tool was being tested and refined, join participation in the Steering Group of Sustainable Master Planning (Score 1) |
| **ENGAGEMENT FEATURE:** | Knowledge utilisation |
| **CONDITION:** | Repeated knowledge use beyond the project |
| EVIDENCE**:** | Evidence for repeated use in reports from different commercial sites, reference made to flagship sustainability tool of the company available online and being offered to clients (Score 1) |
| **OPPORTUNITY:** | Ownership of the tool, full knowledge on how to use it (Score 1) |

Table 27 Sustainable Eastside: Evidence for engagement features and conditions

**SUSTAINABLE EASTSIDE**

| | |
|---|---|
| **ENGAGEMENT FEATURE:** | Trustful relationship |
| **CONDITION:** | Frequency of direct interactions |
| EVIDENCE**:** | Reference made to multiple meetings taking place throughout the duration of the project (Score 1) |
| **OPPORTUNITY:** | Collaborative work, extended beyond original scope with time (Score 1) |
| **ENGAGEMENT FEATURE:** | Trustful relationship |
| **CONDITION:** | Equity of relationship |
| EVIDENCE**:** | Reference made for both sides benefiting the relationship and growing shared understanding (Score 1) |
| **OPPORTUNITY:** | Collaborative work, extended beyond original scope with time (Score 1) |
| **ENGAGEMENT FEATURE:** | Trustful relationship |
| **CONDITION:** | Future plans |
| EVIDENCE**:** | Reference made to future intentions of working and some reference made to how this might be possible but no specific plans (Score 0) |
| **OPPORTUNITY:** | Existing collaboration perceived as beneficial (Score 1) |
| **ENGAGEMENT FEATURE:** | Communication leading to mutual understanding |
| **CONDITION:** | Jargon-free communication |
| EVIDENCE**:** | Reference made to jargon being an obstacle initially and being overcome by both sides adjusting their language (Score 1) |
| **OPPORTUNITY:** | Repeated purposeful interaction (Score 1) |
| **ENGAGEMENT FEATURE:** | Communication leading to mutual understanding |
| **CONDITION:** | Frame of reference |

| | |
|---|---|
| **EVIDENCE:** | Reference made to growing mutual understanding of each other's strengths and weaknesses; secondments allowing personal experience of the other side (Score 1) |
| **OPPORTUNITY:** | Repeated purposeful interaction; people movement between contexts (Score 1) |
| **ENGAGEMENT FEATURE:** | Movement of all types of knowledge |
| **CONDITION:** | End-user engagement with knowledge |
| **EVIDENCE:** | Reference to discussions and debates where sustainability issues were explored in the context of specific developments; Reference to practitioners making decisions based on those discussions implying tacit understanding guiding decision making (Score 1) |
| **OPPORTUNITY** | Flexible and open relationship, full access to knowledge (Score 1) |
| **ENGAGEMENT FEATURE:** | Movement of all types of knowledge |
| **CONDITION:** | Contribution to research process |
| **EVIDENCE:** | Reference made to practitioners being subject to research rather than contributing to research prior to collaborative work evolving; collaboration was not focussed on scoping and doing new research but accessing research knowledge by practitioners through researchers (Score 0) |
| **OPPORTUNITY:** | Not a typical research project (Score 0) |
| **ENGAGEMENT FEATURE:** | Knowledge utilisation |
| **CONDITION:** | Knowledge flexible for adaptation |
| EVIDENCE**:** | Reference made to researchers providing insights from research into discussions on practical solutions and practitioners using elements of it to inform their decisions while working on the regeneration project (Score 1) |
| **OPPORTUNITY:** | Access to expertise, flexible approach to problem solving (Score 1) |

| | |
|---|---|
| **ENGAGEMENT FEATURE:** | Knowledge utilisation |
| **CONDITION:** | Facilitation or witnessing knowledge use |
| **EVIDENCE:** | Reference made to practitioners accessing the expertise to address current issues emerging in the project they were involved in (Score 1) |
| **OPPORTUNITY** | Academics involved in debates on the solutions for an on-going regeneration project (Score 1) |
| **ENGAGEMENT FEATURE:** | Knowledge utilisation |
| **CONDITION:** | Repeated knowledge use beyond the project |
| EVIDENCE**:** | NA (Score 0) |
| **OPPORTUNITY:** | Learning from interaction and previous application of knowledge; Access to knowledge through academics (Score 1) |

Table 28 ISSUES: Evidence for engagement features and conditions

| **ISSUES** | |
|---|---|
| **ENGAGEMENT FEATURE:** | Trustful relationship |
| **CONDITION:** | Frequency of direct interactions |
| EVIDENCE**:** | There is no evidence that any researchers and end users have met more than two times as a result of the intervention of the ISSUES project (Score 0) |
| **OPPORTUNITY:** | Project provided several opportunities for researchers and practitioners to attend joint events, however attendance on those events was random and interactions between participants were not monitored (Score 0) |
| **ENGAGEMENT FEATURE:** | Trustful relationship |
| **CONDITION:** | Equity of relationship |
| EVIDENCE**:** | NA (Score 0) |
| **OPPORTUNITY:** | ISSUES intended to provide both researchers and practitioners with an equal opportunity to present and listen to each other during events (Score 1) |
| **ENGAGEMENT FEATURE:** | Trustful relationship |
| **CONDITION:** | Future plans |
| EVIDENCE**:** | NA (Score 0) |
| **OPPORTUNITY:** | There were no mechanisms in place that would enable building future collaborations between researchers and end users NA (Score 0) |
| **ENGAGEMENT FEATURE:** | Communication leading to mutual understanding |
| **CONDITION:** | Jargon-free communication |
| EVIDENCE**:** | Feedback from the initial events confirmed that academic jargon was used and presented as an obstacle to understanding between event participants. Subsequent events were designed to avoid jargon both with regards to format and speakers. There is also evidence for the effort that was made to ensure |

| | |
|---|---|
| | dissemination materials produced were jargon free. No feedback was received (Score 1) |
| **OPPORTUNITY:** | Events and dissemination materials (publications, website, videos) adapted to language of target audience (Score 1) |
| **ENGAGEMENT FEATURE:** | Communication leading to mutual understanding |
| **CONDITION:** | Frame of reference |
| **EVIDENCE:** | N/A (Score 0) |
| **OPPORTUNITY:** | N/A (Score 0) |
| **ENGAGEMENT FEATURE:** | Movement of all types of knowledge |
| **CONDITION:** | End-user engagement with knowledge |
| **EVIDENCE:** | N/A (Score 0) |
| **OPPORTUNITY** | Only explicit knowledge could be mobilised using dissemination channels (Score 0) |
| **ENGAGEMENT FEATURE:** | Movement of all types of knowledge |
| **CONDITION:** | Contribution to research process |
| **EVIDENCE:** | N/A (Score 0) |
| **OPPORTUNITY:** | N/A (Score 0) |
| **ENGAGEMENT FEATURE:** | Knowledge utilisation |
| **CONDITION:** | Knowledge flexible for adaptation |
| EVIDENCE**:** | N/A (Score 0) |
| **OPPORTUNITY:** | N/A (Score 0) |
| **ENGAGEMENT FEATURE:** | Knowledge utilisation |
| **CONDITION:** | Facilitation or witnessing knowledge use |
| **EVIDENCE:** | N/A (Score 0) |
| **OPPORTUNITY** | N/A (Score 0) |
| **ENGAG. FEATURE** | Knowledge utilisation |
| **CONDITION:** | Repeated knowledge use beyond the project |
| EVIDENCE**:** | N/A (Score 0) |
| **OPPORTUNITY:** | N/A (Score 0) |

### 9.4. Results: Engagement benefits

Assessed case studies presented different approaches to knowledge exchange. All contained engagement practices permitting direct engagement between researchers and practitioners, however the nature of that engagement spanned from one-off events to long-term collaboration allowing or preventing development of other *engagement benefits*.

Following the assessment of the engagement conditions, case studies differed with regards to how likely they were to display *engagement benefits* believed to increase the effectiveness of knowledge exchange. The likelihood here is not a statistical probability but a measure of average. Case 2 received the highest score (*2.0*) where all *engagement conditions* were met and corresponding *engagement benefits* were assessed as highly likely, as both opportunity for their occurrence and evidence that they occurred were present. Case 3 received a score of *1.6* that was seen as *engagement benefits* being *likely* to have occurred. Case 1 scored *1*, with three *engagement benefits* to be at least *likely* and one *possible but unlikely* to occur. Case 4 scored *0.3* with two *engagement benefits* assessed as *unlikely,* one *possible but unlikely* and only one *likely* to occur (Tab.29& 30).

Table 29Average scores engagement features

| | | Case 1 | Case 2 | Case 3 | Case 4 |
|---|---|---|---|---|---|
| Communication / Mutual understanding | Jargon | 1.0 | 2.0 | 2.0 | 2.0 |
| | Frame of reference | 1.0 | 2.0 | 2.0 | 0.0 |
| | Average | 1.0 | 2.0 | 2.0 | 1.0 |
| Movement of all types of knowledge | engagement with knowledge | 0.0 | 2.0 | 2.0 | 0.0 |
| | involvement in research stages | 1.0 | 2.0 | 0.0 | 0.0 |
| | Average | 0.5 | 2.0 | 1.0 | 0.0 |
| Trustful relationship | Frequency of meetings | 2.0 | 2.0 | 2.0 | 0.0 |
| | Equity of relationship | 1.0 | 2.0 | 2.0 | 1.0 |
| | Future plans | 1.0 | 2.0 | 1.0 | 0.0 |
| | Average | 1.3 | 2.0 | 1.7 | 0.3 |
| Knowledge utilisation | Knowledge flexible for adaptation | 1.0 | 2.0 | 2.0 | 0.0 |
| | Facilitation /witnessing knowledge use | 2.0 | 2.0 | 2.0 | 0.0 |
| | Repeated knowledge use | 1.0 | 2.0 | 1.0 | 0.0 |
| | Average | 1.3 | 2.0 | 1.7 | 0.0 |
| Overall average | | 1.0 | 2.0 | 1.6 | 0.3 |

Table 30 Likelihood asseement for engagement feature

| | Case 1 | Case 2 | Case 3 | Case 4 |
|---|---|---|---|---|
| Communication / Mutual understanding | Likely | Highly Likely | Highly Likely | Likely |
| Movement of all types of knowledge | Possible but Unlikely | Highly Likely | Likely | Unlikely |
| Trustful relationship | Likely | Highly Likely | Likely | Possible but Unlikely |
| Knowledge utilisation | Likely | Highly Likely | Likely | Unlikely |

## 9.5. Discussion: Engagement benefits

### 9.5.1. *Engagement benefits and emerging models*

The analysis of the four cases divides them into two groups:

- Group one, with Case 2 and 3, where all *features of engagement* were assessed as *likely* or *highly likely*
- Group two, with Case 1 and 4, where at least one feature of engagement was *possible but unlikely* or *unlikely*.

When analysed with regards to the likelihood of the presence of *engagement benefits*, the case studies present themselves on a spectrum with Case 2 (co-production of knowledge') *most likely*, followed by Case 3, Case 1 and Case 4 (dissemination) being *least likely*. The case studies on the extreme ends of this spectrum represent what literature refers to as the linear push model for Case 4 and the interactional, co-production model for Case 2. Cases 1 and 3 present a more complex picture, with some features present and some absent. As a result, 4 different models emerge:

- 'Consultancy model' (Case 1), where experts deliver a solution for a client (Fig 10).
- 'Co-production of knowledge model' (Case 2) where equal partners focus on the development of a tangible result or product.

- ‘Advisory model’ (Case 3) where equal partners focus on evidence based decision making for real world problems.
- ‘Dissemination model’ (Case 4), where engagement aims at spreading existing knowledge.

### 9.5.2. *Consultancy model*

Case 1 represents a project where collaboration is frequent and long term, creating opportunities for other *engagement benefits* to be present, but evidence is missing or contrary to the *conditions of engagement* being met, with two exceptions: (i) the aforementioned *Frequency of meetings* and (ii) *Facilitation /witnessing knowledge use*. Project records suggest that the *Frequency of meetings* was mostly associated with close collaboration with regard to data collection. The latter condition of engagement (*Facilitation/witnessing knowledge use*) was a result of the fact that researchers created software tool to analyse data collected collaboratively or provided by practitioners and generated results tailored to the practitioner’s needs, further witnessing them being used in a policy paper. At the same time, practitioners only participated in the *Research stages* of data collection and dissemination. They also did not *engage with the knowledge* in any other way than reading, listening and discussing in a group setting during workshops. The roles of both parties resembles a relationship between expert and client, where solutions are tailored and adapted but the recipient of the solution does not participate in a generation of the solution. In the context of literature, the model corresponding to some extent with Case 1 is a linear pull model of knowledge exchange with elements of the interactional model. The features of the model also resemble a transactional relationship established as a result of commercial consultancy (Figure 10).

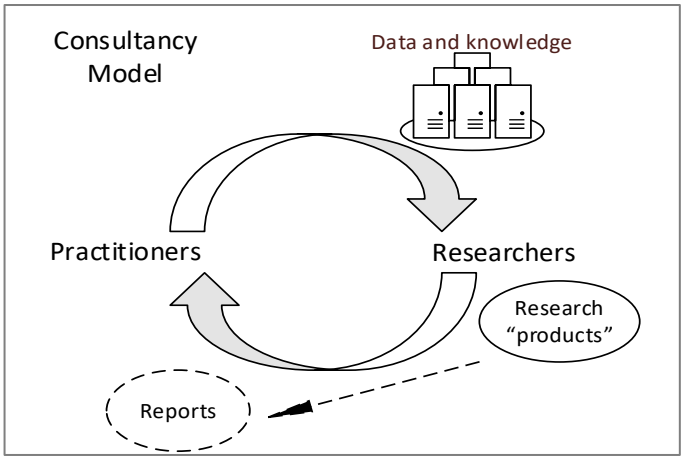


Figure 10 Consultancy model of engagement

### 9.5.3. *Co-production of knowledge model*

Case 2 presents a model of interaction, where parties create a trustful, long-term relationship driven by a common goal: the development of a tool. Both parties participated in all stages of the research and the development process. Their collaborative research aimed to tailor and adapt the content and format of knowledge from previous research to its application context. In the process both sides acquired in-depth understanding of the theoretical foundations and workings of the tool, though the software development side is led by practitioners and the corresponding new set of skills remains with them.

Both parties overcome communication challenges and develop a shared frame of reference. The knowledge generated from this collaboration is adapted, tested, and embedded in the context of practice generating data and insights for the practitioner and feeding into the teaching and research of researchers (Figure 11).

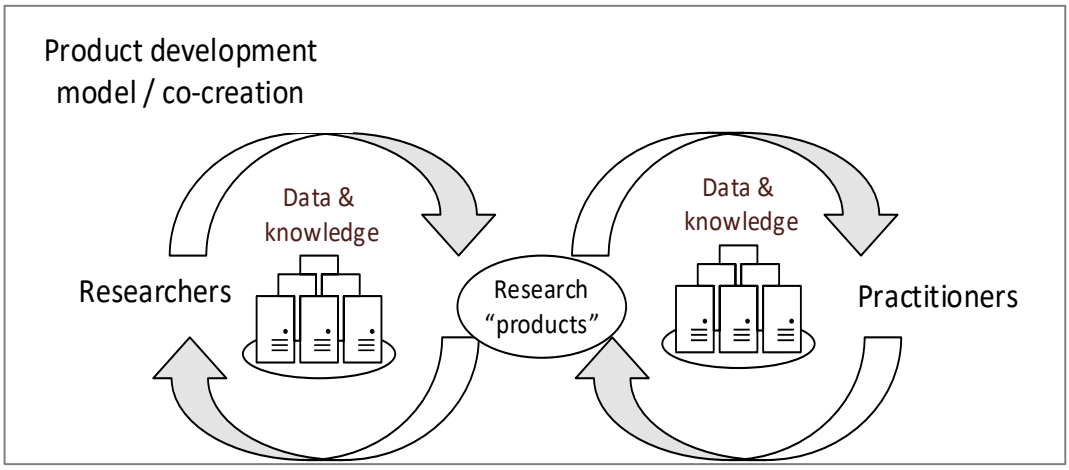


Figure 11Co-production of knowledge model of engagement.

### 9.5.4. *Advisory model*

Case 3 represents a model of interaction where both researchers and practitioners create a trustful, long-term relationship during which communication and mutual understanding is established. The engagement conditions for movement of all types of knowledge are met in that real world problems are discussed in an on-going fashion and solutions are generated as part of a collaborative effort. The problems are of a different nature and content, and no tools or other tangibles are produced as a result - which would enable practitioners to go on without the input of researchers. In the context of literature, this model falls under the interactional category (Figure 12).

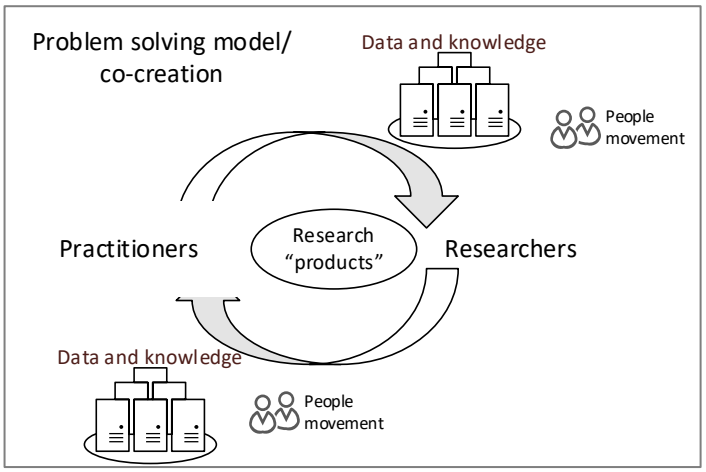


Figure 12 Advisory model of engagement

### 9.5.5. ***Dissemination model***

Case 4 has only met the engagement condition of *Jargon/jargon free communication* where opportunities were created and materials were tailored to present specialist knowledge in a jargon-free fashion. Remaining *features of engagement* were either unlikely (*movement of all types of knowledge and knowledge utilisation*) or *possible but unlikely*. This suggests that the establishment of relationships between researchers and practitioners is unlikely, although it cannot be ruled out as it might have been established as a result of meetings at events (Figure 13).

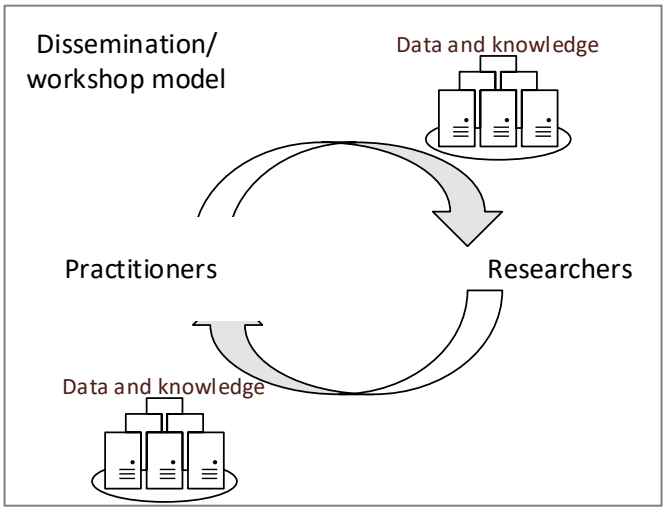


Figure 13 Dissemination model of Engagement

## 9.6. Discussion on the method

### 9.6.1. *Measures of 'evidence' and 'opportunity'*

The measure of *opportunity* was added to the measure of *evidence* following the assumption that although sometimes *evidence* was not available, the circumstances pointed out that the engagement could have been developed nevertheless. Therefore, there was an opportunity for *engagement benefit*. This followed the logic that it is reasonable to assume that parties who work collaboratively, meet frequently, treat each other as equals, and make joint plans for the future, are highly likely to have established a trustful relationship. At the same time, it is still likely for them to have established a trustful relationship if one of the above conditions has not been met. For example, if they work collaboratively but there is a hierarchy in the relationship, or they do not intend to work together in the future or they only met two times. Furthermore, it is unlikely, but possible, that a trustful relationship if more than two conditions are not met. This is because, as long as there is an opportunity to interact, the other factors of the social world can influence people's behaviours, experiences and decisions in an unpredictable way. However, if the parties do not have any opportunity to interact directly, it is highly unlikely for them to develop any real relationship, never mind a trustful one.

### 9.6.2. *Comparability of knowledge exchanged in projects*

The projects were not directly comparable and access to details was also varied. Two projects were focussing on production of a software tool (Case 1 and 2) , one was focussing on advice regarding specific emerging needs of a regeneration project (Case 3), and one was entirely focused on dissemination (Case 4). This provided a rich spectrum of possible scenarios whereby knowledge exchange is used, but it also reduced the direct comparability and required the framework to compromise on specificity. For example, the measurement for the *engagement benefits*: *movement of all types of knowledge* and *utilisation of knowledge* was scored in the same way, irrespectively of the specific knowledge that was the subject of exchange (tool, skills and understanding, end of project results). Narrowing down the specific knowledge would result in slightly changed results. For example, if assessment of *Utilisation of knowledge* focussed only on the research derived end-results in their original form, Case 1 would have scored the highest, as the results were embedded in policy. Case 2 has also embedded the knowledge in a commercialised product, but the end-results that inspired the work were adapted heavily, to the extent that it became a new project altogether. In addition, Sustainable Eastside

and ISSUES would have scored lowest as they did not produce results in the same way. If the ability to *reuse knowledge embedded in a tool* was the main criterion, it would have only regarded Case 1 and 2, which both produced tools. In Case 1, practitioners were not involved in the tool development, testing or using – they were only given the results. By contrast, in Case 2 practitioners led on development of the tool, therefore they were left with the ability and rights to use it for other projects.

### 9.7. Method: Impact Assessment Framework

To examine what impact the SUE consortia engagement techniques have made, the cases were mapped against the categories of impact: *Understanding*, *Change of practice*, and *Impact of the change of practice.* The broad areas of impacts consisted of smaller impacts that could be achieved by projects. The category of impact: *Understanding* was represented by 10 specific subcategories of impacts. The category of impact: *Change of practice* was represented by 8 discreet subcategories of impact, and *Impact of Change of Practice* by 7. The framework assumes that only the aforementioned sub-categories of impacts can be achieved within each of the broader categories. This list of categories and sub-categories of impact is based on the literature review studying approaches to evaluation of large projects (Fazey et all). Furthermore, the instances of impact that could be evidenced were compared against the total number of impacts in each category for each case study. Proportion of impacts evidence vs. all that were assessed by the framework, were compared in the diagrams.

### 9.8. Data: Impact Assessment Framework

Data for the four case studies are presented in the Tables 31, 32, 33 and 34, representing Case 1: AUNT SUE, Case 2: IDCOP, Case3: Sustainable Eastside and Case4: ISSUES respectively.

Table 31 AUNT SUE impacts mapping.

| AUNT SUE | |
|---|---|
| Evidence available | No evidence |
| Understanding (proportion 4/10) | |
| - Increased knowledge, awareness or understanding<br>- Skills: new skills learned by participants<br>- Provision of information: amount/quality of new information provided<br>- Identification of further needs or action | - Attitude and attitude change<br>- Intention of behaviour change<br>- Confidence: increased confidence in participants<br>- Innovation: creation of innovations and new ideas<br>- New structure: new networks or structures are set up, communication is improved<br>- Symbolic/political use of knowledge |
| Change of practice (proportion 4/8) | |
| - Decisions made<br>- New evidence integrated into policy/strategy<br>- Further sharing of knowledge<br>- Use of knowledge | - Use of new technology or tool<br>- Change in organisational process or decision making<br>- Creation of new institution, system or project: Includes only outcomes of KE, not the KE itself<br>- Individual behaviour change |
| Impact of change of practice (1/7) | |
| - Benefits for stakeholders involved | - Ecological health<br>- Social and economic welfare<br>- Social equity/participation<br>- Business performance<br>- Quality of health and health care<br>- Capacity built |

Table 32 IDCOP impact mapping

| IDCOP | |
|---|---|
| Evidence available | No evidence |
| Understanding (10/10) | |
| - Intention of behaviour change<br>- Increased knowledge, awareness or understanding (reference in interviews)<br>- Skills: new skills learned by participants (reference in interviews)<br>- Attitude and attitude change (towards academic research and sustainable assessment of master planning)<br>- Provision of information: amount/quality of new information provided (reports and other research)<br>- Confidence: increased confidence in participants (both sides referred to working together and confidence regarding reliability of results )<br>- Innovation: creation of innovations and new ideas (software)<br>- Identification of further needs or action<br>- New structure: new networks or structures are set up, communication is improved<br>- Symbolic/political use of knowledge | |
| Change of practice (8/8) | |
| - Individual behaviour change<br>- Use of new technology or tool<br>- Decisions made<br>- New evidence integrated into policy/strategy<br>- Change in organisational process or decision making<br>- Creation of new institution, system or project: Includes only outcomes of KE, not the KE itself<br>- Further sharing of knowledge<br>- Use of knowledge | |
| Impact of change of practice (4/8) | |
| - Impact of change of practice<br>- Business performance<br>- Capacity built<br>- Benefits for stakeholders involved | - Ecological health<br>- Social and economic welfare<br>- Social equity/participation<br>- Quality of health and health care |

Table 33 Sustainable Eastside impact mapping

| Sustainable Eastside | |
|---|---|
| Evidence available | No evidence |
| Understanding (8/10) | |
| - Increased knowledge, awareness or understanding (reference in interviews)<br>- Skills: new skills learned by participants<br>- Attitude and attitude change<br>- Intention of behaviour change<br>- Confidence: increased confidence in participants<br>- New structure: new networks or structures are set up, communication is improved<br>- Provision of information: amount/quality of new information provided<br>- Identification of further needs or action | - Innovation: creation of innovations and new ideas<br>- **S**ymbolic/political use of knowledge |
| Change of practice (5/8) | |
| - Individual behaviour change<br>- Decisions made<br>- New evidence integrated into policy/strategy<br>- Change in organisational process or decision making<br>- Use of knowledge | - Further sharing of knowledge<br>- Use of new technology or tool<br>- Creation of new institution, system or project: Includes only outcomes of KE, not the KE itself |
| Impact of change of practice (3/7) | |
| - Business performance<br>- Capacity built<br>- Benefits for stakeholders involved | - Ecological health<br>- Social and economic welfare<br>- Social equity/participation<br>- Quality of health and health care |

Table 34 ISSUES impact mapping

| ISSUES | |
|---|---|
| Evidence available | No evidence |
| Understanding (3/10) | |
| - Increased knowledge, awareness or understanding<br>- New structure: new networks or structures are set up, communication is improved<br>- Provision of information: amount/quality of new information provided | - Skills: new skills learned by participants<br>- Attitude and attitude change<br>- Confidence: increased confidence in participants<br>- Innovation: creation of innovations and new ideas<br>- Identification of further needs or action<br>- Symbolic/political use of knowledge<br>- Intention of behaviour change |
| Change of practice (0/8) | |
| | - Individual behaviour change<br>- Decisions made<br>- Use of new technology or tool<br>- New evidence integrated into policy/strategy<br>- Change in organisational process or decision making<br>- Creation of new institution, system or project: Includes only outcomes of KE, not the KE itself<br>- Further sharing of knowledge<br>- Use of knowledge |
| Impact of change of practice (0/7) | |
| | - Ecological health<br>- Social and economic welfare<br>- Social equity/participation<br>- Quality of health and health care<br>- Business performance<br>- Benefits for stakeholders involved<br>- Capacity built |

### 9.9. Results: Impact Assessment Framework

Visual inspection of the tables with data suggests that the Case 2 and Case 4 are on the far ends of the spectrum of evidence availability, where Case 2 can evidence almost all impacts listed in the framework, and Case 4 almost none. Cases 1 and 3 are more similar.

Calculating percentages of impacts achieved versus potential impacts, suggests that Cases 2 (co-production model) and 3 (advisory model) perform best with regards to all categories of impacts (Table 35 and 36). Case 4 (dissemination model) performs worst and Case 1 (consultancy model) achieves half of the impacts on *Understanding* and *Change of practice* but performs far worse, compared to Case 4 in the category *Impact of Change of Practice* (Figures 14 and 15).

Table 35 Results of impact assessment (% of impacts evidenced)

| Area of impact | Case 1 | Case 2 | Case 3 | Case 4 |
|---|---|---|---|---|
| Understanding | 40 | 100 | 80 | 30 |
| Change of practice (ChOP) | 50 | 100 | 63 | 0 |
| Impact of ChOP | 14 | 57 | 43 | 0 |

Table 36 Results of impact assessment (numbers of impacts evidenced)

| | Case 1 | Case 2 | Case 3 | Case 4 |
|---|---|---|---|---|
| Understanding | 4 | 10 | 8 | 3 |
| Change of practice (ChOP) | 4 | 8 | 5 | 0 |
| Impact of ChOP | 1 | 4 | 3 | 0 |

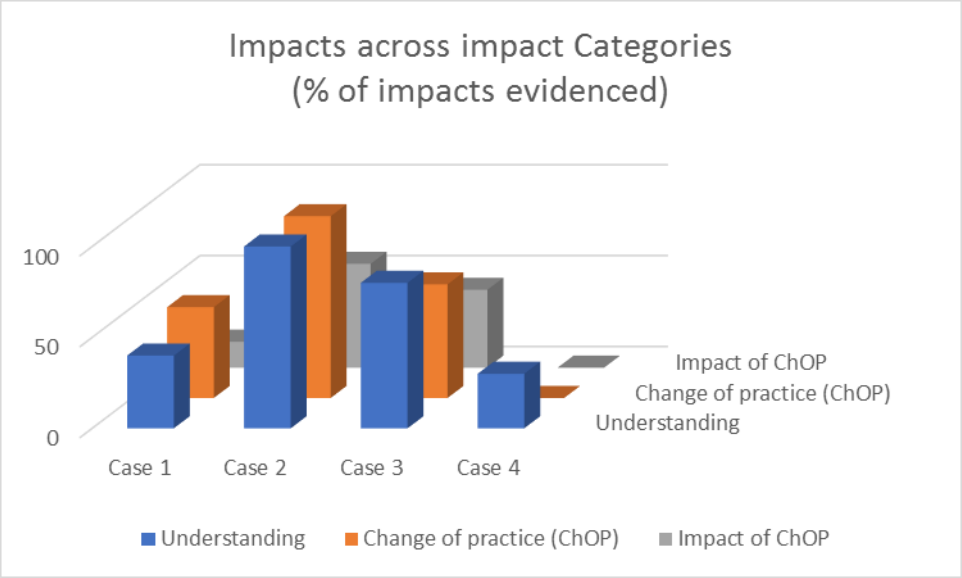


Figure 14 Impacts across impact Categories (% of impacts evidenced)

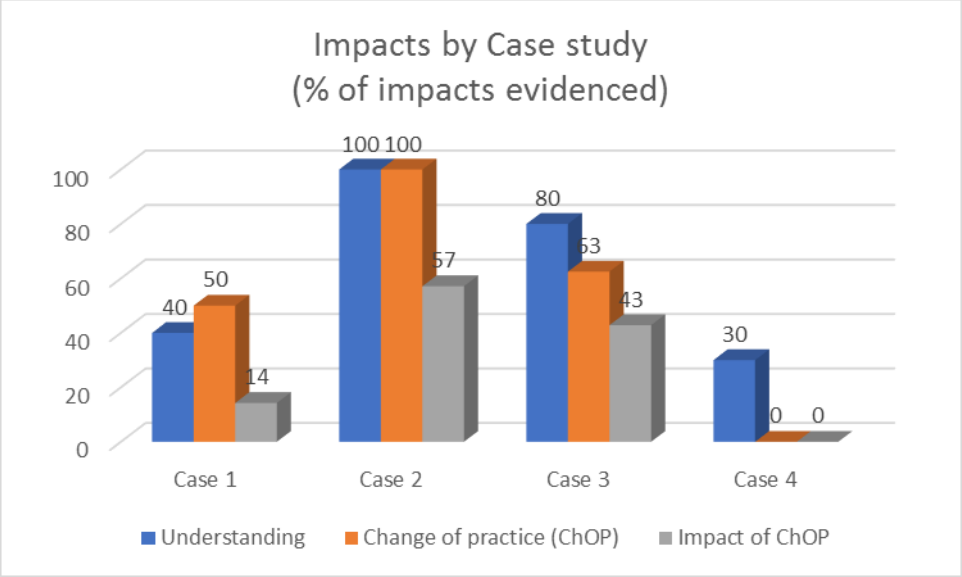


Figure 15 Impacts by Case study (% of impacts evidenced)

### 9.9.1. *Impact on 'Understanding'*

The mapping exercise suggests that all projects have made an impact on the area of *Understanding*. However, Cases 2 and 3 would have achieved bigger proportion of possible impacts (Case 2-100%, Case 3-80%), Case 1 achieved half of possible impacts and Case 4, 30%. Comparing the numerical data with the types of impacts the Case studies achieved in the area of *Understanding* and additional research records reveals the differences between them. The main difference was with regards to capacity building. In Cases 2 & 3 practitioners gained skills that equipped them with the ability to manage, adapt and reuse the knowledge gained in the process. By contrast, in Case 1, the skills gained by practitioners related to a limited amount of data collection. As a result, they

were not able to use the tool developed by the project or otherwise adapt the data already collected and analysed by researcher. Case 4 did not enable practitioners' learning.

### 9.9.2. *Impact on "Practice Change"*

The impact category of *Practice Change,* was best evidenced by Case 2 and 3 (100%, 63% respectively). In Case 2, a new tool was created and embedded in the company's practices. In Case 3, the *Change of practice* was in the company's approach to evidence seeking and decision making. In Case 1 new results generated by research (via the new software tool) were included in a local planning policy. In Case 4, a new structure was created by the ISSUES project: the 'connect'. It was a government supported online platform for urban practitioners (virtual community of practice).

### 9.9.3. *Impact of Change of Practice*

In the impact area *Impact of Change of Practice*, Case studies 2&3 achieved highest (57% &43% or 4&3 subcategories of impacts out of 7 respectively). Case 1 only achieved one sub-category (equal 14%) and Case 4 did not have evidence for any impact within this category.

Qualitative analysis of the impact areas reveal additional details on the scope of those impacts. In Case 1, the *Impacts of Change of Practice* referred to very specific geographical locations. The report generated by the software tool, created by researchers, was customised to that specific location by researchers by using local data. By contrast, in Case 2, the impact is likely to affect multiple locations over time, as it was not the results generated by the tool, but the tool itself that was the subject of knowledge exchange. It was incorporated by the company as a standard tool to be used across its global offices. The tool supports a sustainable master-planning process and is flexible enough to adjust to local contexts. The impact of Case 3 is also geographically limited, however skills gained by practitioners (working for the company which collaborated with researchers) may be used on future projects. As the skills are less definable than a software tool, it is not possible to anticipate when, how, and where they will be used.

## 9.10. Discussion: Impact Assessment Framework

The impact assessment framework consisted of mapping the impacts achieved by four case studies against a list of impacts in three broad categories of *Understanding*, *Change of practice* and *Impact of Change of Practice*. This mapping exercise enables to get an overall picture of impacts across the various areas, and identify potential causal

relationships between the categories, which require further research. The comparison of the four case studies reveals that the achievement of more impacts in the area of *Understanding* corresponds with the achievement of more impacts in the area of *Change of practice*. The same relationship applies to the areas of *Change of Practice* and *Impact of Change of Practice*.

However, the framework provides only the first step in any impact assessment and requires qualitative data to make sense.

Solely mapping the impacts may provide some indication of potential pathways to impact. For example, scoring high in the impact area of Understanding may provide an indicator for possible upcoming impacts in the area of Change of Practice. Scoring in the area of Change of practice requires the collection of qualitative data with which to understand its scope, reach and ability to make further impact.

# CHAPTER 10 CONCLUSIONS

## 10.1. Introduction

This thesis investigated knowledge exchange practices and their impact on urban sustainability. The urban environment as a context for utilisation of new knowledge, mobilised by knowledge exchange, is a complex one. It is highly regulated and hierarchical, risk averse and shared between multiple, interconnected stakeholders. Improvement of sustainability within such a complex context is somewhat challenging to define, as ways to achieve it are changing along with growing understanding and technological advancements. Literature refers to it as a process of change, called sustainability transition (Markard 2012). The change needs to take place on various levels of the socio-technical system, the description of which resonates with the characteristics of urban environment. In the context of the above, the knowledge exchange practice aim, to make an impact on the process of sustainability transition, requires a definition be given, and measures be found, appropriate for reflecting this complexity.

The case studies in the thesis provided examples of projects in different stages of impact development. The historical case study of SUDS illustrated the process from the introduction of a new sustainable concept to an advanced stage of its implementation in the regulated and hierarchical structure of policy and practice of the urban environment in Scotland. It provided the long-term view that many contemporary projects would not possess.

The case studies from Sustainable Urban Environment illustrated efforts and impacts achieved by individual projects, but without sufficient time to assess which of those impacts will remain in places.

The thesis formed part of the ISSUES project, one of the SUE programme funded projects.

### 10.1.1. *Aim, objectives and questions*

The overall research aim was to explore how knowledge exchange from research can be improved to impact on urban sustainability. The thesis was addressing two objectives, further explored through research questions: Objective 1: Identify and assess characteristics of knowledge exchange processes that affect their effectiveness in making an impact. The objective was approached by addressing the following research questions: (1) What knowledge exchange practices are used by researchers and practitioners in the area of urban sustainability? (2) How to define effectiveness of knowledge exchange in

the context of urban sustainability? Objective two aimed to develop a method for the assessment of knowledge exchange impacts on urban sustainability. It was addressed by exploring the following questions: (1) How should we measure impact on urban sustainability? (2) What impacts have been achieved by SUE research projects? and (3) How did the new sustainable SUDS practice became embedded in the built environment?

## 10.2. Objective 1: Identify and assess characteristics of knowledge exchange processes that affect their effectiveness in making an impact

Case studies investigated in the thesis presented a wide range of KE interventions, spanning individual practices and large projects. The historical case study showed how all kinds of KE tools were used throughout the extended period of time and remain in use. These included linear models of KE, where research was communicated to the recipients via dissemination, and interactional models where engagement based KE was used to build the skillset, influence attitudes and change behaviour. The SUE case studies demonstrated how, seemingly similar projects have taken different approaches to KE and achieved different results. Over their short lifespan, they could only use certain practices. The KE features developed organically in all projects: in two case studies the underlying structure for KE was planned from the outset (AUNT SUE and ISSUES), and in the other two it was triggered as a response to practitioners' needs (IDCOP and Sustainable Eastside).

### 10.2.1. *Engagement benefits – features improving effectiveness of KE.*

The literature review identified engagement features, which were believed to improve the effectiveness of knowledge exchange. These included: *trustful relationships*, *jargon free communication, movement of all types of knowledge -enabling learning, and research utilisation*. The first three refer to the actual features of the process, whereby the last one refers to the ability to witness or support research utilisation. These features were called *engagement benefits*. The *engagement benefits* were first studied in the context of the historical case study of SUDS, although the KE taking pace in SUDS was not directly comparable to that of the individual research projects, as it was not between researchers and practitioners, but amongst practitioners themselves, albeit often with the support of researchers. The most salient characteristics of the long-term process, evident in the SUDS case study were (i) contextualisation of the new knowledge to the local requirements, and (ii) the importance of learning by doing all along the process. In the framework, the first falls under the *engagement benefit*: *utilisation of knowledge.* The latter refers to *engagement benefit*: *movement of all types of knowledge*. Every time

SUDS was being applied to a new context, it required new research and adaptation in order to fit within its pre-existing technical standards and regulations. The contextualisation of the SUDS knowledge required the understanding and skills of practitioners involved, both tacit and explicit, which they developed throughout the process, through learning by doing, trial and error and through expert facilitation. The *engagement benefit of trustful relationship* was referred to with regards to groups of practitioners implementing SUDS, sometimes involving academics and other times, not.

### 10.2.2. ***Engagement Benefits Framework***

The *Engagement Benefits Framework* was created in a following way. It was based on an assessment of *conditions of engagement*, believed in the literature to facilitate development of *engagement benefits*. The assessment of each *condition of engagement* was based on two factors; (i) whether there was any evidence that it had occurred and (ii) whether there was an objective opportunity for it to occur. This measure of *evidence* and *opportunity* was applied to distinguish between projects, which seemed similar in terms of the possibility of the development of engagement benefits, but which ultimately developed differently.

The *Engagement Benefit Framework* provides the following insights about the SUE case studies, which were assessed according to the Framework's criteria. The division of projects displaying various *engagement benefits* mirrors the division between the linear and interactional models of knowledge exchange. For example, IDCOP and Sustainable Eastside fall into interactional models, and ISSUES and AUNT SUE into linear models. Furthermore, the assessment using the *Engagement Benefits Framework* identifies four engagement models: (i) the *consultancy model,* where experts deliver a solution for a client; (ii) the *co-production of knowledge* model, where equal partners focus on the development of a tangible result or product; (iii) the *advisory model*, where equal partners focus on evidence-based decision making for real-world projects; and (iv) the *dissemination model*, where the main aim is to spread the research knowledge.
It can be concluded that the most interactive models, displaying most *engagement benefits* (*co-production and advisory models)* achieve impacts on all impact categories, *Understanding, Change of practice* and *Impact of Change of Practice*.

### 10.2.3. ***Knowledge transferred***

The research suggests that the knowledge that becomes the focus of knowledge exchange is not always the end-result of a research project. It can involve other by-products of a

research process (methodology) or focus entirely on the disciplinary knowledge of researchers, including that derived from other people's research. Flexibility to follow the demand and preference of practitioners with regards to knowledge increases the possibility of knowledge exchange making a lasting impact on the real world.

In two out of the four cases, the subject and type of knowledge that was exchanged developed organically as a result of interactions. Case 2 used methodology from a previous project to start a collaboration focussed on turning this methodology into a new decision-supporting tool. The knowledge exchanged included the aforementioned methodology (as opposed to end-results), and the disciplinary knowledge of the researchers involved, including knowledge derived from the publications of other people. Case 3 used disciplinary knowledge as well as the results from research (their own and others') to support and inform decisions of practitioners (not the end-results). In the remaining two cases, the end-results were the subject of interventions: Case 1 followed a linear model of developing the research, generating results, and handing over the results, which were then embedded in a policy paper. Case 4 disseminated both research results from the SUE consortia, as well as their own research findings.

### 10.2.4. *Capacity building is essential for impact on urban sustainability*

The research suggests that the final impact of changed practice in the construction industry takes place through the application of sustainable solutions in individual geographical locations, bit by bit. Therefore, repetition of the use of knowledge and flexibility of that knowledge to fit the new set of conditions is essential. For this, the practitioners need to have the ability to apply the knowledge repeatedly,

beyond the duration of the project and without facilitation. They need to own the knowledge and have confidence and skills to apply it. Hence capacity building emerges as an essential feature of KE aiming at impact on urban sustainability.

Capacity building was a distinctive feature of the cases that scored highest on the *KE Impact Assessment Framework*, in all categories of impact. Concluding, the engagement-based, interactional models of knowledge exchange, to which the 'co-production' and 'advisory' engagement models are most likely to facilitate the achievement of impacts on urban environment, lasting beyond the duration of the project.

Not all engagement and direct interactions provide opportunities for engagement features to develop. The framework of engagement features provide a useful checklist for

researchers to investigate whether they have considered all the important factors required for their KE efforts to be most successful.

## 10.3. Objective 2: Develop a method for assessment of knowledge exchange impacts on urban sustainability

### 10.3.1. *Measuring impact on urban sustainability*

Progress towards sustainability is defined in the literature as the transition of a socio-technical system. It is a multi-faceted and multi-layered process that is being altered as its understanding develops. As such, contributions to that process are diverse and not easily comparable.

Characteristics of the built environment correspond well with those of the socio-technical system: interconnected and multi-stakeholder, and at the same time fragmented and project based. The industry that creates the built environment – the construction industry – is locked-in to the specific methods of production, some of which require fundamental, and other, cumulative, changes to become more sustainable. In this complex picture, it is challenging to single-out interventions that can be traced all the way back to its impacts on urban sustainability. At the same time, knowledge exchange from research is assumed to lead to impact on urban sustainability. To address this challenge a literature review was undertaken to identify the evaluation methods appropriate to address it. The traditional methods of impact assessment based on commercialisation value or frequencies of interventions were disregarded an inappropriate. Instead, a study by Fazey (2014), which analysed the approaches to impact evaluation on over 170 complex environmental projects was selected to form basis of a new method. It categorised impacts investigated by the projects into three areas: Impact on *Understanding*, *Change of Practice* and *Impact of Change of Practice*. It highlighted the challenges to proving causality encountered by projects operating in complex environments affected simultaneously by external factors. The method took format of a framework for the assessment of impacts. It listed the impacts under each category, which were used as a benchmark for impacts in each category. The case studies investigated were mapped onto the framework and compared with each other.

Before the framework assessment was applied to the SUE case studies, it was piloted on the SUDS case study. The following conclusions were made about impact of knowledge exchange in the urban environment. In spite of the diversity of the KE, the founding ingredient of the engagement-based practices was the social process involved. Therefore,

the impact on the area of *Understanding* was essential for other impact to take place. The implication of this statement is that knowledge exchange being a social process can make a direct impact only on the parties participating in the process. Hence it cannot be directly linked to impact on the real world processes unless through the practitioners it engages. Exceptions are the rare occasions where researchers become practitioners themselves (through spin-outs, secondments, etc.) where they can themselves influence the practice. For example, in Case 2, the creation of a software tool was aided by researchers but the use of the tool and the embedding of it in the company practice was done by the practitioners themselves, though credibility resulting from collaborative work with universities might have supported the process.

Furthermore, the historical case study of SUDS draws attention to the complex picture of changes corresponding to the *Change of Practice*, and the *Impacts of Change of Practice*. The SUDS is a sustainable innovation and contributes to the process of sustainability transition in the area of surface water management. When adopted by different stakeholders, it required reinvention and contextualisation, resulting in multiple instances of *Change of Practice*. The following features characterised the process:

- *Change of practice* triggers further *Change of Practice* before it impacts on the real world developments whence sustainability can be improved.
- *Change of practice* in one organisation can trigger changes across the sector.
- Similar *Change of Practice* is likely to take place across each domain involved, sometimes undergoing the same processes of contextualisation.
- *Change of Practice* taking place organically can be interrupted in the middle of its development by other external factors, such a larger geo-political events or higher-level policies. It is therefore difficult to determine its impact until implemented at later stages. The history of SUDS in Scotland shows how several serendipitous political events changed the country's regulatory and legislative system, and provided windows of opportunity but also interrupted the bottom-up developments of SUDS).
- The alignment process within the built environment required a collaboration process involving all stakeholders, and has lasted for the more than 15 years.

As demonstrated by the SUDS implementation case study, the process of introduction of a sustainable innovation is long and multifaceted. Individual innovation may branch-out into multiple innovative solutions, applications, technologies, and policies as they are being implemented in different contexts and by different stakeholders.

### 10.3.2. *The KE Impact Assessment Framework - method for impact assessment*

The KE Impact Assessment Framework allows mapping the impacts without the necessity of providing causal relationships, although these may become apparent or could be assumed and further investigated. It aims to capture the scattered picture of possible impacts achieved by the projects, which cannot be ordered in a causal pathway to impact, but reflects well the multi-layered nature of the built environment.

The framework was tested on the four case studies from the Sustainable Urban Environment project and generated the following results. The description below uses the names of the engagement models, which were identified during research. The models of engagement with the highest engagement benefits (co-production and advisory) achieved highest scores on the *KE Impact Assessment Framework*. They achieved most impacts on the area of *Understanding*, which was expected. They also achieved many impacts in the area of *Change of Practice* and *Impact of Change of Practice*. The 'consultancy model' performed less well on all areas, and with the smallest effect on the area of *Impact of Change of Practice*. The 'dissemination model' made little impact on the area of *Understanding*, and *Change of Practice*, with none on the area *of Impact of Change of Practice.*

Analysis of the details of impacts falling into the category of *Change of Practice* highlights that the 'dissemination' and 'consultancy' models' impacts in this area were achieved by implementing knowledge in the exact format it was prepared by them (AUNT SUE), or by tailoring it to the implementation demand (ISSUES). In both cases, the adjustment, or the original knowledge was prepared by researchers. The 'co-production' and 'advisory' models created knowledge that was adaptable, and adaptable by practitioners – hence it could fit within the changing circumstances and be contextualised as required beyond the project duration. To illustrate the difference, a comparison between the 'consultancy' and 'co-production' models can be made. They produced software tools, but only the latter equipped practitioners to use and own it beyond the project.

The *KE Impact Assessment Framework* offers a new way of mapping projects' impact on complex environments, where different impacts may be taking place at different times and a linear way of reporting them is not possible. The framework was only tested on four projects and further development of impact subcategories and their assessment, as well

as testing on larger number of projects, may reveal additional insights into the impact development of knowledge exchange on sustainability transition within the urban environment.

### 10.4. Addressing the aim

The overall research aim was to explore how knowledge exchange from research can be improved to impact on urban sustainability. The research concluded that to improve knowledge exchange from research into urban sustainability the KE practices need to be made as flexible and empowering as possible to practitioners. It is the practitioners, who, through their improved practices, influenced by the new knowledge, drive the impact towards sustainability, when research projects are finished. The ability of practitioners to contextualise, reuse, and further develop the impact is essential, as illustrated in the historical case study of SUDS and contemporary case study of IDCOP. The case study of SUDS highlights that the process of reinvention and contextualisation can take many years (more than 15 years for SUDS) before it can have a consistent impact in urban sustainability. Throughout this time, it need to be driven by practitioners. To enable practitioners do that, research, through KE can make an impact on the area of *Understanding* of practitioners. This category of impact includes: knowledge, skills, and attitudes. Impact on the area of *Understanding* is more likely to take place where knowledge exchange is characterised by *engagement benefits.* The *Engagement Benefits Framework* can assess KE projects with regard to their potential impact on the area of *Understanding* and *Change of Practice* by evaluating the opportunities for development of *engagement benefits*. Assessment of *engagement benefits* can indicate possible scenarios for the development of knowledge exchange projects and can offer insights into the implication of adopting them. The scenarios are represented by engagement models, where: 'co-production' and 'advisory' models have the biggest impact on *Understanding*, and so facilitate capacity building in practitioners; the 'consultancy' model may produce *Change of Practice*, but is likely to have limited impacts beyond the duration of the project; and the 'dissemination' model is only able to raise awareness.

The following further conclusion is that impacts should be studied in the context of wider socio-technical changes within the relevant sector, in order to be able to see the role of impacts falling under the *Change of Practice* category on the bigger picture of change.

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